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Science Edition 2017

canola DIGEST

The Source for Canada's Canola Growers

SCIENCE EDITION 2017

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Research pays dividends

All three of us are growers. We are also the research committee chairs for your provincial canola organizations. Wearing both of these hats, we have a responsibility to make sure the levy dollars you entrust to us are used wisely. We know that well-spent research investment provides a very good return on our levy payment.

You want payback proof? Start with the grower experiences in this magazine, then work through the research summaries. As you read through this Canola Digest Science Edition 2017, you'll think of lots of ways to apply the research and improve profitability on your own farm.

At **SaskCanola**, the goals with research investment are to decrease production risk, increase sustainability and enhance producer profitability. In 2015-16, SaskCanola contributed over $2.2 million toward 74 canola-related research projects and programs. These include research into rotation of clubroot-resistance genes, assessing the impact of the new midge species, and pre-harvest desiccation practices to dry down crop for straight-combining. SaskCanola budgeted $2.4 million for research in 2016-17. When growers invest in research, it opens up other sources of funding. For every $1 that SaskCanola commits to research, it leverages another $3 to $4 from its partners.

Alberta Canola spends about 25 per cent of its budget on research. This year, it put money into projects on long-term sustainable rotations, finding new sources of clubroot resistance genes and a weather-based real-time insect monitoring program. In 2017, Alberta Canola spent around $1.5 million on 59 new and ongoing research projects. Like SaskCanola, Alberta Canola generated around $3 from funding partners for every grower dollar it spent on research this year.

Manitoba Canola Growers spent more than $580,000 directly on research in 2016-17, and expects that number to increase in 2017-18. While the production area in Manitoba ranks third in overall size, the Manitoba Canola Growers are able to extend the impact of its research investment dramatically, reaching an average of $12 in research partnership and funding dollars leveraged for every grower dollar it spent on research in 2016-17. Targeted research topics include verticillium and clubroot monitoring and management, agronomic performance of multiple hybrid and open-pollinated varieties, and more.

Our three organizations often work together to jointly fund research. Many of the projects described in this magazine have funding from two or three of our organizations. One example is the popular variety-comparing Canola Performance Trials. Another is the lygus and flea beetle thresholds study, led by Hector Carcamo. Grower organizations invested $426,000 in that project and if it helps growers avoid unnecessary insecticide application on just 40,000 acres, it pays for itself. In reality, this information will help us all make better decisions on millions of acres per year and for many years to come. Dividends from that one study alone will be huge.

SaskCanola and Alberta Canola also worked with the Government of Canada to fund an Agri-Science Project titled "Canola Disease Management Tools for the Prairies – Blackleg and Sclerotinia". See updates for these studies starting on page 26.

Finally, through our representation on the Canola Council of Canada (CCC), all three grower organizations helped to select and fund *Growing Forward 2* Science Cluster projects. These are featured throughout Canola Digest Science Edition 2017.

Helping to move these discoveries into our on-farm practices, the CCC agronomy specialists also review the research and talk to the scientists. They look for practical and profitable applications that end up in Canola Watch articles, in videos and in demonstrations at canolaPALOOZA, canoLAB and other important events our organizations help fund and plan. In time, new ideas trickle throughout agronomy and extension staff and those ideas that are truly sound become part of the best practices for canola crop establishment, fertility management, integrated pest management and harvest management.

Eventually, new approaches to profitable canola production cycle back to everyone in one way or another, spreading the dividends across the Prairies. And where do all these new approaches start? With research.

canola DIGEST
Science Edition 2017

COMPLETED PROJECTS

Credit: iStock.com/Antagain

GLOSSARY OF ABBREVIATIONS | These abbreviations will appear throughout the magazine:

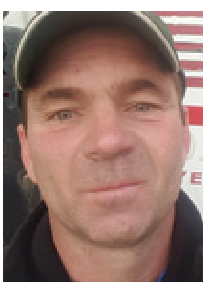
Alberta Canola/ ACPC .... Alberta Canola Producers Commission
Manitoba Canola Growers/ MCGA ... Manitoba Canola Growers Association
SaskCanola/ SCDC .... Saskatchewan Canola Development Commission
CCC ..... Canola Council of Canada
AAFC .... Agriculture and Agri-Food Canada
ABC ..... Alberta Barley Commission
ACIDF ... Alberta Crop Industry Development Fund
ADF ..... Agriculture Development Fund (a Saskatchewan program)
AF .... Alberta Agriculture and Forestry
AFC ..... Agriculture Funding Coalition
AIBIO .... Alberta Innovates Bio Solutions
AIP ...... Agri-Innovation Program (AAFC matching initiative for *Growing Forward 2*)
APG ..... Alberta Pulse Growers
ARDI .... Agri-Food Research and Development Initiative
ASCA .... Alfalfa Seed Commission of Alberta
ASP ..... AgriScience Project (GF2)
AWC ..... Alberta Wheat Commission
CARP .... Canola Agronomic Research Program (grower organization funded)
CGDP .... Canola Germplasm Development Project (SaskCanola funded)
GF2 ..... *Growing Forward 2* (federal funding program)
IHARF ... Indian Head Agricultural Research Foundation
NSERC .. Natural Sciences and Engineering Research Council of Canada
PAMI .... Prairie Agricultural Machinery Institute
SPG ..... Saskatchewan Pulse Growers
SWDC ... Saskatchewan Wheat Development Commission
WGRF ... Western Grains Research Foundation

RESEARCH PAYS DIVIDENDS

ONGOING PROJECTS

RESEARCH-DRIVEN PROGRAMS

RESEARCH PAYS DIVIDENDS



JODY KLASSEN | MAYERTHORPE, ALBERTA

As farmers, we can do a lot of our own testing, but science provides verifiable results that back up our tests and help us make better decisions that fit the context of our own farms. One bit of farmer-funded science that has made us a lot of money is work to show how later swathing and, in some cases, straight-combining can produce higher yields. For another example, people may not realize that growers have paid for a lot of research around blackleg that has allowed us to continue to sell our canola into China. The value of that research in dollars to producers is mammoth. And one reason we could respond to China and provide that research so quickly is because we invested ahead of time in the structures to get it done.

Banding N shows clear yield advantage with lower N rates

KEY RESULT: In this east-central Manitoba study comparing surface, shallow-band and deep band nitrogen applications, any yield effect from nitrogen losses were minimal when nitrogen was applied at 100 per cent of the recommended rate. Losses were still happening, but the N rate compensated. At 70 per cent of recommended rate, the yield-damaging effect of N loss from surface applications shows up much more clearly.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Canola Response and Minimizing Nitrogen Losses in Two-Pass Seeding-Fertilization Systems with Varying Placement Methods in Manitoba," Mario Tenuta, University of Manitoba

FUNDING: Manitoba Canola Growers, Koch Fertilizers

With increasing pressure to complete field operations faster and the trend to using fertilizer custom applicators, a segment of growers in Western Canada are transitioning to surface applications of granular urea. This represents a departure from the recommended practice of deep banding.

To re-test this practice using modern hybrids and tools, this three-year study compared canola yield results for surface application, shallow banding (0.5" to 1") and deep banding (1.5" to 4") of nitrogen at 100 per cent and 70 per cent of recommended rates. For year-three of the study, Tenuta and his team also added fall broadcast application treatments.

Surface applications of fertilizer increase the risk that nitrogen will be lost through NH_3 volatilization. Volatilization occurs when urea hydrolysis elevates pH levels and increases the concentration of gaseous NH_3 around granules. When fertilizer granules are deep banded, gaseous NH_3 formed around urea granules can be inter-converted to ammonium (NH_4^+), a non-volatile ion which subsequently absorbs to negatively charged soil particles. This does not happen with surface applications. Gaseous NH_3 is lost with surface applications.

That is why deep banding is considered the superior technique. But deep banding does require additional horsepower, can slow field operations at seeding time, and may also have undesirable effects on seedbed quality and moisture content.

Figure 1. Canola yield for N at 70% of recommended rate

Figure 2. Canola yield for N at 100% of recommended rate

The study was designed to compare shallow banding and surface broadcasting to deep banding for losses and yield. Trials also tested the loss-reducing benefits of SuperU and Agrotain, which contain active ingredients that inhibit the enzymatic or microbial processes that contribute to nitrogen loss from soils.

RESULTS

As expected, deep banding did reduce N loss when compared to shallow banding and surface application. These losses, though, tended to be higher in lightest soil used in the study. Trials were done at six sites in east-central Manitoba, from the heavy Red River Valley clay to Carman clay loam.

What is noteworthy is that when nitrogen was applied at 100 per cent of recommended rates, these losses had little consequence on yield (See Figure 2.). This is not surprising as N rates were at provincial guideline recommendations based on the soil test. At these rates, N would be above or near the top end of the N response curve for yield.

However, for the 70-per-cent N rate, banding increased yield compared to surface application (See Figure 1.). There was no statistical difference between banding depths, though deep banding had numerically one bu./ac. more yield than shallow banding. There was no effect of N source (urea, SuperU or Agrotain treated) on yield at the 70-per-cent rate. For the 100-per-cent rate, the effect of banding on yield for N treatments was not evident.

For surface applications, yield was much higher for spring versus fall application. SuperU or Agrotain broadcast in the fall provided no benefit. Surface applications in the fall are not recommended, as many previous studies have concluded.

DEEP BANDING STILL THE BEST

Deep banding in the spring or late fall is still the best method to increase nitrogen use efficiency, reduce losses (and therefore greenhouse gas emissions) and, for rates below the soil test recommendations, to increase yields. For growers who have implemented broadcast applications for logistical purposes, these are best done in the spring to reduce losses. Consider use of a urease-inhibitor product with spring broadcast applications.

This study was limited to east-central Manitoba. Trials across other soil types and growing regions across the Prairies would provide valuable yield insight for canola farmers, especially for those using rates below their soil-test recommendations.

Optimum row spacing depends on many factors, including weeds

KEY RESULT: Canola is relatively insensitive to increasing row spacing. Farmers have many factors to consider in determining their optimal row spacing, including weed and residue management strategies.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Investigating wider row spacing in no-till canola: Implications for weed competition, response to nitrogen fertilizer, and seeding rate recommendations (2013-2016)" Chris Holzapfel, Indian Head Agricultural Research Foundation (IHARF)

FUNDING:
SaskCanola

Find all previous Science Editions online at **canoladigest.ca** and more on research discoveries at **canolaresearch.ca**.

Pros and cons exist for both narrow and wide row spacing in canola production. This is a complex issue that can affect entire production systems. Although several previous studies have focused on row spacing in canola, there have been many improvements over the past twenty years in genetics, seeding/fertilization equipment and weed control options. Relevant research was required under zero- or minimum-tillage, continuous cropping systems using seeding equipment with side-banding capabilities and modern, herbicide-tolerant hybrids.

Led by Chris Holzapfel of IHARF, a multi-year study was initiated in 2013 to evaluate the impacts of wider row spacing on canola performance and to investigate implications for seeding rate, nitrogen (N) fertilizer and weed management recommendations. Three separate field trials were conducted where row spacing levels of 25, 30, 36, 41 and 61 cm were combined with varying side-banded urea rates, seeding rates and in-crop herbicide treatments. For all trials, a glufosinate-ammonium-tolerant (Liberty Link) canola hybrid was seeded using a SeedMaster plot drill. Unless otherwise dictated by protocol, canola was seeded at a target rate of 115-120 seeds per square metre.

Generally, the research showed that canola plant populations declined as row spacing was increased. When averaged across all years and treatments, plant populations declined by 28 per cent (from 85 down to 62 plants per square metre) when row spacing was increased from 25 cm to 61 cm. Increasing row spacing also resulted in slight but significant delays in flowering and maturity. However, row spacing effects on seed yield were small and, in some cases, non- significant, and were always considerably less than environment or other management effects.

Results also suggest that seeding rates should not likely be reduced below typically recommended rates as row spacing is increased. However, there was little benefit to using seeding rates exceeding 90 seeds per square metre when planting canola at 61 cm row spacing.

Results of the side-banded N treatments showed a significant reduction in plant densities with increasing rates of side-banded N in all three years. Despite the negative effects on emergence, canola responded well to side-banded N with sequentially increasing yields right up to 150 kg/ha N in all three years, even at 61 cm spacing. Overall, the results of this study suggest that N requirements of canola are likely similar regardless of row spacing; however, extremely high rates of side-banded N combined with wide row spacing can increase risk of seedling injury.

WEED EFFECT

Although it is generally accepted that weed competition may be compromised at wide row spacing, this study did not show any practical, short-term effects of row spacing that could not be managed with well-timed herbicide applications.

The study did reinforce the overall benefit of weed management. Canola grown without weed control resulted in average yield losses of 21 per cent, with similar loss observed regardless of row spacing. However, for growers dealing with or looking to prevent the development of herbicide-tolerant weeds, narrow row spacing can be an important component to integrated management strategies.

YIELD EFFECT

Narrower row spacing consistently produced amongst the highest yields, particularly when combined with high rates of side-banded N. However, row spacing as wide as 61 cm was always viable under the environmental conditions encountered and when combined with timely, effective weed removal. Canola growing on wider row spacing did take longer to achieve canopy closure, but the effects on maturity were negligible.

Although many of the major drawbacks to narrower row spacing are more logistic than agronomic (higher operating and input costs), this can also make it considerably more difficult to seed into heavy crop residues. The numerous, longer-term benefits of slightly wider row spacing could be a topic for further study as this may lead to better seed placement in heavy residues, increased organic matter retention, more timely seeding, better utilization of existing equipment, lower seed-bed preparation requirements and more.

Generally, this research concludes that canola is relatively insensitive to increasing row spacing and there are many factors to consider in determining the optimal row spacing for individual farms. Pros and cons exist for both narrow and wide row spacing – this is a complex issue that can affect entire production systems and, therefore, there is no likely single row spacing that is optimal for all farm operations.

First yield-loss model for blackleg on the Prairies

KEY RESULT: This study quantified how reducing blackleg can substantially improve canola yields. Growers should continue to select blackleg-resistant canola varieties and follow best-practice recommendations to manage this disease.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Development of a blackleg yield loss model and assessment of fungicide resistance in Western Canadian populations of *Leptosphaeria maculans*," Stephen Strelkov, University of Alberta

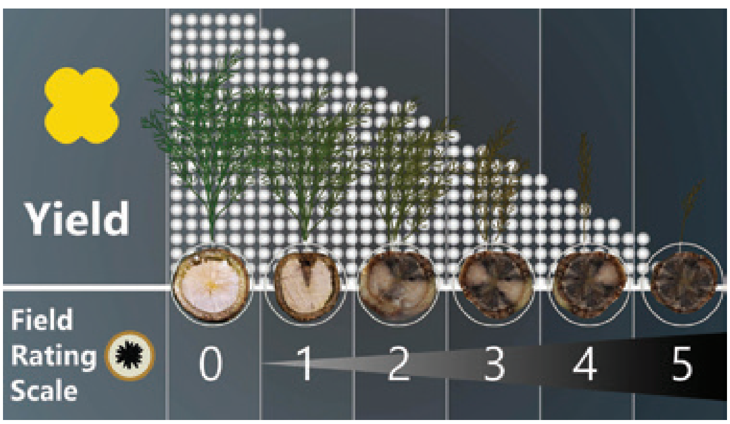
FUNDING:
SaskCanola, Alberta Canola, GF2

PEER-REVIEWED JOURNAL ARTICLES:

Fraser, M., Hwang, S.F., Ahmed, H.U., Akhavan, A., Stammler, G., Barton, W., and Strelkov, S.E. 2017. Sensitivity of Leptosphaeria maculans *to pyraclostrobin in Alberta, Canada. Can J. Plant Sci., 97(1): 83-91*
Hwang, S.F., Strelkov, S.E., Peng, G., Ahmed, H.U., Zhou, Q., and Turnbull, G.D. 2016. Blackleg (Leptosphaeria maculans) *severity and yield loss in canola in Alberta, Canada. Plants, 5(3), 31 (11pp). DOI 10.3390/plants5030031*

Blackleg in Canada has been managed largely through the use of resistant cultivars. But in recent years the virulence of *Leptosphaeria maculans* populations has shifted, resulting in the erosion of genetic resistance. This loss of resistance became evident in 2012 when many canola crops sown to resistant (R) and moderately-resistant (MR) cultivars were heavily infected with blackleg and suffered severe yield losses.

This four-year study led by University of Alberta's Stephen Strelkov aimed to establish the relationship between blackleg disease severity and canola yield loss and to determine if there is any fungicide resistance in *L. maculans* populations from Western Canada. The project objectives included development of a yield-loss model and ensuring sustainability of fungicide approaches to blackleg management.



This graphic representation of Strelkov's research shows how increased blackleg severity, indicated by the stem-damage cross sections, relates to smaller plant size and lower yield potential.
Credit: Scott Gillies

In each year of the study, greenhouse and field experiments were conducted to determine the relationship between blackleg disease severity and yield in a susceptible cultivar (Westar) and in MR (1950RR) to R (46S53RR) canola hybrids. As expected, disease severity in the R and MR varieties was lower than in the susceptible variety over all site years. There were also significant differences in number of pods per plant with 46S53RR having the greatest and Westar the lowest. Seed yield was also 120-128 per cent greater for 46S53RR and 1950RR.

Regression analysis showed that pod number and seed yield declined as disease severity increased in all site years. There were considerable variations among the site years with pod number decreasing by 18-45 per plant and seed yield decreasing by 0.92-2.65 g per plant for every one-point increase in disease severity. When averaged over five site-years, this transforms to estimated yield losses in Westar of 17.2 per cent for each point increase in blackleg severity based on the 0-5 severity scale shown in the diagram.

FUNGICIDE OBJECTIVE

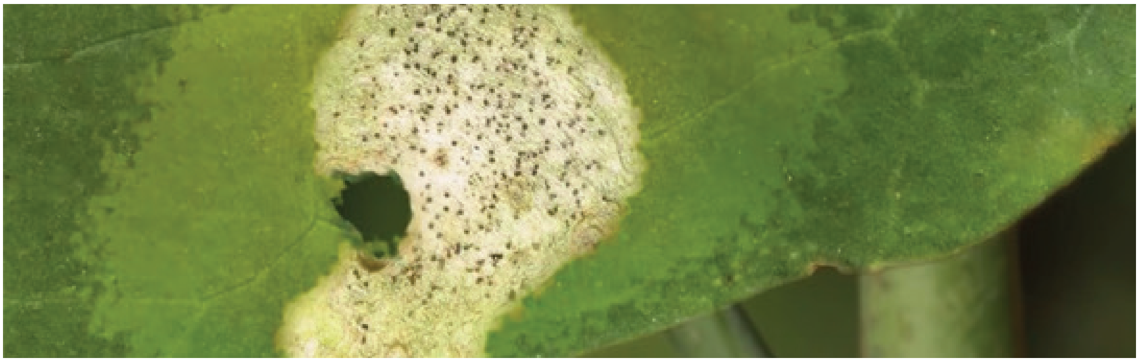
Strobilurin fungicides can be used to manage blackleg of canola, but they have a high risk of selecting for resistance in fungal populations. To assess fungicide sensitivity, a total of 117 single-spore *L. maculans* isolates were collected from infected canola residues in six fields located in the Alberta counties of Camrose, Lacombe, Ponoka, Strathcona and Wetaskiwin.

The isolates were grown on fungicide-amended agar plates and growth inhibition was calculated in comparison to non-amended controls. The effective concentration of pyraclostrobin fungicide needed to inhibit growth by 50 per cent was determined to be 0.09 mg per litre based on 13 randomly selected isolates. To identify fungicide resistance, a discriminatory dose 69-fold greater was used to screen all 117 isolates where <50 per cent growth inhibition would be considered insensitive. Resulting values ranged from 66.6 to 100 per cent with a mean of 84.3 per cent, indicating that all of the isolates were sensitive to pyraclostrobin. However, these isolates represented a relatively small number of fields and additional work will be required to confirm this conclusion for subsequent monitoring of shifts in sensitivity.

While most canola cultivars grown in Alberta have moderate to high resistance to blackleg, there is always a risk that genetic resistance will be overcome, especially if the same cultivar is planted repeatedly in short rotations. Growers should continue to select blackleg-resistant canola varieties and follow best practices for residue management and crop rotation.

From this study, the first yield-loss model for blackleg of canola has been developed for Western Canada. This is important information both for informed pest management decisions and for communicating with external stakeholders.

Developing new blackleg resistance



Above: Blackleg lesion on a canola leaf.

KEY RESULT: Plant breeders have made significant progress towards transfer of blackleg resistance from the *B. carinata* genome into *B. napus* canola.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Molecular cytogenetics of blackleg resistance in the *Brassica* B-genome, and introgression of resistance into *B. napus* through recurrent backcrossing,"

Habibur Rahman, Department of Agricultural, Food and Nutritional Science, University of Alberta

FUNDING:
Alberta Canola, ACIDF, Canadian Foundation of Innovation, University of Alberta

Canola breeding programs have utilized *Rlm3* genes for resistance to the common blackleg (*Leptosphaeria maculans*) pathotypes on the Prairies. However, this resistance was found ineffective against the newly emerging pathotypes, such as PG3, PG4 and PGt. As a result, researchers are working to identify new sources of resistance and incorporate those genes into canola.

At the University of Alberta, the canola breeding program has focused on incorporating disease resistance from *Brassica carinata* into *Brassica napus* canola. Among the three *Brassica* genomes (A, B and C), the A and C genomes, which are present in canola *B. napus*, are much closer to each other than to the B genome. Because the B genome, which is present in *B. carinata*, is very distant from the A and C genomes, this makes the introgression of a gene from the B genome into A or C genome of *B. napus* a challenging task.

The resistance in *B. carinata* to the more virulent PG4 blackleg pathotype is believed to be under the control of more than one gene. As a result, the introgression of multiple genes from the B to the A/C genome may be needed for PG4-type resistance in *B. napus*. Identification of the B-genome chromosomes of *B. carinata* carrying the resistance genes will be a step forward to achieving the goal.

OBJECTIVE

The objectives of this research were:

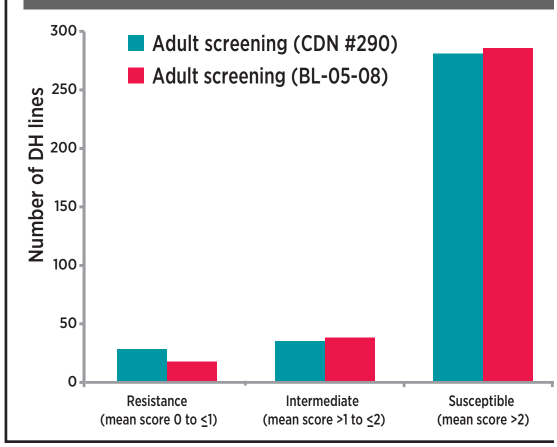
1. To identify the B-genome chromosome(s) of *B. carinata* carrying resistance to blackleg PG4-type isolate through molecular cytogenetic study and application of double-haploid (DH) technology, and
2. To transfer this resistance into the A/C genome of *B. napus*.

RESULTS

Of the total of 661 double-haploid (DH) lines produced and 405 lines tested for cotyledon and adult-plant resistance to PG4- and PGt-type isolates, more than 20 per cent carried adult-plant resistance while the occurrence of cotyledon resistance was low (about two per cent of plants). The occurrence of adult-plant resistance in 77 backcross-derived pedigree families was also similar to the level of resistance found in the DH population. The chromosome B3 or B7 alone was not able to confer strong adult-plant resistance, but the presence of these two chromosomes exerted greater resistance in the plants.

Number of DH lines carrying cotyledon (upper) and adult-plant (lower) resistance to *L. maculans* PG4-type isolate #290CDN and PGt-type isolate #BL05-08

Source: Habibur Rahman, University of Alberta



Molecular marker analysis also indicated that some of the lines may lack the B genome chromosomes, but low seed set in these plants indicate that fragments of B chromosome(s) might be present in these plants. These lines are currently being tested in Australia for resistance to this disease. Given the complexity of this research project, the plant breeders made significant progress towards introgression of PG4- and PGt-type resistance from the B genome of *B. carinata* into *B. napus* canola.

COMPLETED PROJECTS

Study proves concept of grouping varieties by blackleg resistance class

KEY RESULT: This study found that matching genetic resistance to dominant pathotype groups in a field is possible, but more work is needed to make this practical for long-term cultivar rotations and overall blackleg management.

PROJECT TITLE, PRINCIPAL INVESTIGATORS: "Development of canola cultivar blackleg resistance groups: Feasibility evaluation," Ralph Lange, Alberta Innovates – Technology Futures

FUNDING: Alberta Canola, WGRF, ACIDF

Table: Interaction between six Leptosphaeria maculans *populations and 34 canola cultivars in indoor cotyledon tests.*

Blackleg disease, caused by the fungal pathogen *Leptosphaeria maculans* was responsible for near-total crop losses experienced in Canadian canola fields prior to adoption of resistant cultivars in the mid-1990s. Unfortunately, *L. maculans* can recombine avirulence (*Avr*) genes to rapidly overcome cultivar resistance, resulting in frequent, serious yield losses.

The Canola Council of Canada and other agencies recommend against re-use of canola cultivars in individual fields, particularly in fields where inoculum load is high, for example under rotational intervals of less than one canola crop in four years. Changing cultivars should slow pathogenic adaptation because different combinations of resistance genes (R-genes) would be presented to pathogen populations that are adapted to previously planted cultivars. But this would only work if the cultivars have different R-genes.

The goal with this study was to determine if canola cultivars could be grouped on the basis of their reaction to *L. maculans*. Producers could then use this information to select cultivars that will perform against blackleg in their fields.

Early experiments confirmed that cultivars could be placed into two loose groups, but grouping was subject to a number of confounding factors, such as inoculum, pathogenic variation and quantitative resistance.

So, Lange and his team began testing a system based on planned deployment and withdrawal of R-genes based on the primary blackleg pathotypes present in a field.

To test this, they challenged a set of Canadian canola cultivars with isolates representing the common pathotypes found across the Prairies. They selected a set of six *L. maculans* isolates from a subsample of 98 cultures collected from 33 locations in Manitoba, Saskatchewan and Alberta that represented the most common *Avr* gene combinations. With its *L. maculans* test population chosen and defined, the team tested a number of canola cultivars by point-inoculating each chosen isolate onto the cotyledons of these cultivars, and evaluating blackleg disease according to standard methods.

An example of their results is presented in the table, which shows the mean disease severity of cotyledon point inoculations, converted to per cent disease severity. The table shows that some cultivars are resistant to each of the six pathotypes tested. Commercial fields tend to have two dominant pathotypes (Larkan and Borhan, unpublished data) which means that cultivars must be simultaneously resistant to two pathotypes in most cases. Pathotypes D and E are most prevalent in Alberta. Therefore, farmers in Alberta may see better results picking cultivars with an R or MR rating for both D and E, but only 15 per cent of cultivars tested had this combination. Pathotypes B and C appear to be most prevalent in Manitoba, but only 12 per cent of the cultivars tested would be simultaneously resistant in this scenario. So, choosing cultivars resistant to two or more pathotypes may be a challenge.

This information will help canola growers make better blackleg resistance choices. But for this resistance grouping system to work in the long term, we need additional major-resistance genes, better knowledge of the efficacy and genetics of quantitative resistance, as well as better information on *L. maculans* population structures over all geospatial scales, and the changes in these structures over time. Emphasis on crop rotation and other blackleg control methods should be increased to reduce reliance on genetic resistance.

Disease severity rating[1] after inoculation with *L. maculans* isolate						
	Blackleg pathotype (from most to least virulent)					
Cultivar[2]	B	C	D	F	E	A
1852	R	R	R	MR	R	R
1849	MR	R	R	MR	R	MR
1840	MR	MR	MS	MS	MS	R
1864	MR	R	MR	MS	MR	R
1886	MR	MS	MR	MR	MR	MR
1835	S	MR	MR	MR	MR	MS
1866	MR	MS	MS	MS	MR	MS
1845	S	S	MS	MR	MS	R
1857	MS	MR	S	S	MS	R
1878	S	S	MS	MS	MS	MR
1848	S	S	MS	MS	MS	MR
1864	S	MS	MS	S	S	R
1858	S	S	MS	MS	MS	MR
1975	S	S	MS	MS	MR	MS
1861	S	S	S	MS	S	R
1913	S	S	MS	MS	MS	MS
1862	MS	S	MS	MS	S	S
1850	S	S	S	S	S	R
1910	S	S	S	MS	S	MS
1874	S	S	MS	S	S	MR
1868	S	S	S	MS	S	MR
1882	S	S	MS	S	MS	MS
1877	S	S	S	MS	S	MR
1911	S	S	MS	S	S	MS
1879	S	S	MS	S	MS	S
1884	S	S	S	S	MS	MS
1870	S	S	S	MS	S	MS
1875	S	S	S	S	S	MS
1934	S	S	S	S	S	MR
1876	S	S	S	S	S	S
Q2	S	S	S	S	S	MR
1854	S	S	S	S	S	S
1873	S	S	S	S	S	S
1859	S	S	S	S	S	S

[1]Percent severity of Westar, mean of 80 observations of disease severity where 0 = no disease and 5=unrestricted lesions with pycnidia, where "R", "MR", "MS", and "S" indicate 0-29.9, 30-49.9, 50-69.9, and 70-100% of Westar, respectively. Average severity on Westar cotyledons was 4.7.
[2]These are Canadian canola cultivars, with the exception of 1934, which originates in Australia. Numbers are used to disguise actual cultivar names.

Digging deeper into the clubroot-canola interaction

KEY RESULT: Significant advances have been made in understanding the role of primary and secondary zoospores in clubroot disease development. This could contribute to new and effective sources of clubroot resistance.

PROJECT TITLE, PRINCIPAL INVESTIGATORS:
"The host-pathogen interaction of *Plasmodiophora brassicae* and canola," Sheau-Fang Hwang, Alberta Agriculture and Forestry

FUNDING:
Alberta Canola, SaskCanola, Manitoba Canola Growers, CCC, AAFC, GF2

PEER-REVIEWED JOURNAL ARTICLES:

Zhang, H., J. Feng, S.J. Zhang, S.F. Zhang, F. Li, S.E. Strelkov, R.F. Sun, and S.F. Hwang. 2015. Resistance to Plasmodiophora brassicae in Brassica rapa and Brassica juncea genotypes from China. Plant Dis. 99:776-779.
Zhang, H., J. Feng, V.P. Manolii, S.E. Strelkov and S.F. Hwang. 2015. Characterization of a pathotype 5-specific gene from the clubroot pathogen Plasmodiophora brassicae. Phytopathology 105: 764-770.
Zhang H., J. Feng, S. F. Hwang, S. E. Strelkov, I. Falak, X. Q. Huang and R. F. Sun. 2016. Study of resistance to clubroot (Plasmodiophora brassicae) in a canola (Brassica napus) doubled haploid population. Can. J. Plant Pathol: 38: 133.
Fei, W.X., S. Rong, J. Feng, S.F. Hwang and S. E. Strelkov. 2016. Expression patterns of selected Plasmodiophora brassicae genes in resistant and susceptible canola. Can. J. Plant Pathol: 38: 128

While much progress has been made recently in Canada toward explaining the interactions between the clubroot pathogen *Plasmodiophora brassicae* and its canola host, many questions remain unanswered. These knowledge gaps need to be filled to fully understand the pathogenic and genetic diversity of *P. brassicae* populations, how the disease develops, infection processes, and the role of primary and secondary pathogen zoospores in disease development. This understanding will provide further tools to help manage and prevent the spread of the disease.

As part of an overall objective to produce the critical information needed to fill these important knowledge gaps, six different studies were implemented. The specific objectives of the research included:

The role of primary and secondary zoospores in infection of canola plants and in inducing host resistance.

How the pathogen invades host tissues, and what mechanisms are involved in the development of clubroot galls.

How to best define pathotypes or races of *P. brassicae*, and to develop molecular tools to more rapidly identify strains.

Study transformation and/or culture of *P. brassicae* to facilitate research into this pathogen.

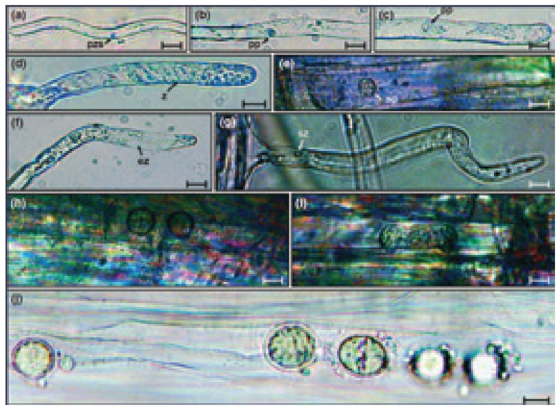
RESULTS

In 2015-16 one gene, designated *Cr811*, was studied, which appears to be present exclusively in pathotype 5 of *P. brassicae*. Analysis indicated that expression of *Cr811* is up-regulated during canola infection, especially in the stage of secondary plasmodia. Primers specific to *Cr811* could distinguish a field isolate of *P. brassicae* belonging to pathotype 5 from two other field isolates representing pathotypes 3 and 8. These findings suggest that *Cr811* is a gene involved in the interaction between host resistance and clubroot pathogenesis, and that it also might serve as a molecular marker for differentiation of pathotype 5 from other pathotypes.

Further work provided insights into the timing of the interaction between the effectors (causal agents) from *P. brassicae* and the canola host. It was found that primary infection is initiated earlier than previously believed. Additionally, primary zoospores can cause secondary infections directly, without causing primary infections. (For background information on primary and secondary infection, read the "Disease Cycle" section under the About Clubroot heading at **clubroot.ca**.)

The results support the hypothesis that primary infection suppresses the initiation of resistance in a susceptible cultivar and also stimulates the resistance reaction in a resistant cultivar. It appears likely that pathogen effectors are recognized at the primary infection stage and that this early interaction between host and pathogen contributes to the resistant or susceptible reaction in the host at the secondary infection stage.

To further understand the different pathotypes of *P. brassicae*, one-week-old seedlings of 13 Brassica genotypes were inoculated with resting spore suspensions representing each of 11 populations and 7 single-spore isolates of *P. brassicae* from Canada, U.S. and China. This research identified five distinct pathogen virulence groupings based on host reactions. This suggests that these different hosts may constitute an effective foundation for the development of a Canadian clubroot differential set, and will be further evaluated in order to more effectively classify pathotypes of *P. brassicae*.



Canola roots at 12 (a), 24 (b), 36 (c), 48 (d), 72 (e-g), 96 (h and i) and 120 hours after inoculation with resting spores of clubroot. pzs = primary zoospore, pp = primary plasmodium, z = zoosporangium, sp = secondary plasmodium, ez = empty zoosporangium, and sz = secondary zoospore.
Credit: Feng, Hwang & Strelkov, 2013

During the research studies, a modified methodology for secondary zoospore generation was developed to enable production of greater amounts of zoospores for larger scale experiments. In the future, this revised methodology may also prove useful for breeding programs that wish to screen for resistance against secondary zoospores (as opposed to resting spores/primary zoospores).

In summary, the research revolved around improving our understanding of the *P. brassicae*/canola interaction. Such knowledge is critical to developing sustainable clubroot management strategies, particularly as they pertain to the production and deployment of genetically-resistant canola cultivars, and the development of effective biological and chemical controls for the pathogen.

Equipment sanitation slows the spread of clubroot

KEY RESULT: Improved equipment sanitation is a rapid and cost-effective strategy to manage the spread of clubroot in canola. Agricultural, oil and gas, and construction industries can apply these techniques.

PROJECT TITLE, PRINCIPAL INVESTIGATORS: "Evaluating physical and chemical methods for cleaning and disinfecting tools, machinery, equipment and other hard surfaces contaminated with clubroot," Ron Howard, Alberta Agriculture and Forestry, Brooks

FUNDING: Alberta Canola, SaskCanola

NEW RESEARCH ON DISINFECTANT: Michael Harding with Alberta Agriculture and Forestry is in the middle of a new project to provide more specific instructions on which disinfectants work best to eliminate living clubroot spores on openers, tires, boots and more. This research will wrap up in April 2018, just in time for seeding season.

Clubroot in canola is a destructive, soil-borne disease now confirmed in several areas across the Prairies. Once a field becomes infested, it is extremely difficult to get rid of the pathogen because it produces long-lived resting spores. Resting spores are mainly spread via contaminated soil carried from field to field by equipment. Farm, oilfield and construction machinery frequently carries soil from one location to another and therefore also carries the greatest risk of spreading clubroot disease.

In 2007, clubroot was added as a declared pest to Alberta's Agricultural Pest Act, followed by the development of the Alberta Clubroot Management Plan to direct farmers and others working in infested fields on ways to prevent the build up and spread of clubroot. Cleaning and sanitation of machinery and equipment was one of the key recommendations in the plan, however, very little was known about the relative efficiency of these methods.

The amount of soil recovered from the four-wheel-drive tractor was estimated at 300 kg, indicating that farm and industrial equipment has a great potential to spread soil from clubroot-infested fields.

A three-year project led by Ron Howard evaluated a wide variety of physical and chemical methods including the efficacy of various disinfectants and thermal treatments against the resting spores of the clubroot pathogen under laboratory and greenhouse conditions. Effective treatments were also evaluated in commercial operations.

In the first year, researchers developed methods and protocols to treat suspensions of clubroot resting spores in the laboratory. The trials compared 10 commercial disinfectants at four concentrations (zero, one-half, one, two and five times the manufacturer's label rate) for recommended exposure times. These treated resting spores were subsequently used to inoculate *Brassica* spp. seedlings, which were grown and monitored under greenhouse conditions for disease development and severity. Spore mortality was rated using the Evan's blue staining analysis and two staining assays were evaluated with thermal treatments at 40.0°C and 60.0°C at various incubation times. In general, with few exceptions, most disinfectants appeared to be highly effective at one or more rates and the higher rates of thermal treatments appeared to be highly effective.

In 2010, a chisel plow and four-wheel-drive tractor and grain cart from a clubroot-infested commercial field were cleaned, pressure washed and disinfected with various products and sampled with sterile cellulose sampling sponges. The sponge samples were subsequently processed and used for bright-field microscopy analysis and plant-bait assays of clubroot resting spores. In 2011, the same methods were used for sampling and testing a centre pivot, chisel plow and four-wheel-drive tractor. In addition, soil and crop residues were collected intermittently during the cleaning process. Soil collected from the four-wheel-drive tractor and chisel plow was quantified and used for plant-bait assays.

The results from the field trials showed that cleaning, pressure washing and disinfection of farm and industrial equipment was effective at limiting the spread of the clubroot pathogen. Generally, most disinfectants appeared to be highly effective at one or more rates, as were higher rates of thermal treatments. All plant-bait assays were negative and all thermal treatments of 40°C to 100°C proved effective at various minimum incubation times. Future trials will include more rates of the highly effective products.

Overall, the results from the laboratory, greenhouse and commercial field trials showed that improved sanitation, including cleaning, pressure washing and disinfection of equipment, is a rapid and cost-effective strategy that can be broadly applied to manage clubroot in canola.

Understanding the importance of pollinators to canola

KEY RESULT: Canola benefits from having abundant pollinators. Ongoing research is determining in what contexts yield and seed quality benefit the most from pollinator activity.

PROJECT TITLE, PRINCIPAL INVESTIGATORS:
"Reliable and effective use of managed bees for canola pollination," Shelley Hoover, Alberta Agriculture and Forestry

FUNDING:
Alberta Canola, SaskCanola, Manitoba Canola Growers

Several surveys and experiments were conducted to investigate the impact of pollinators on canola yield and pollination efficacy, and to generate a better understanding of bee behaviour.

Surveys were conducted around Lethbridge and Grande Prairie in 2014 and 2015 to identify which pollinators were present in commercial canola and their impact on yield. Pollinator diversity and abundance were surveyed at four distances from the field edge (five, 20, 100 and 400 metres into the field) and those counts were related to pollen counts and seed yield.

In fields stocked with honey bee hives, honey bees were the dominant flower visitor, followed by large flies (*Muscidae, Anthomyiidae, Calliphoridae*), hoverflies (*Syrphidae*), and wild bees. In unstocked fields, large flies were the dominant flower visitor.

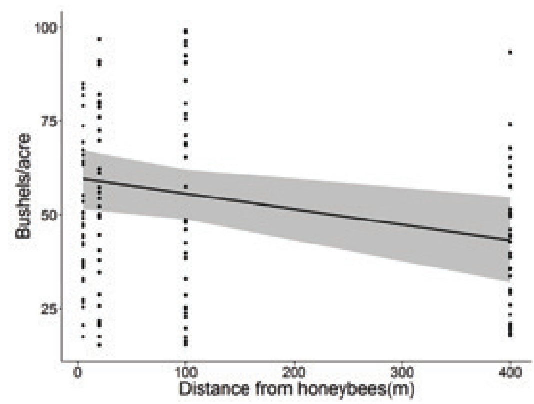
While bee abundance declined with distance from the field edge, pollen deposition on flower stigmas did not decline in 2014, indicating that bee pollination accounts for only a portion of the total pollen deposited on stigmas in these commodity canola fields.

HONEY AND LEAFCUTTER BEES IMPORTANT IN SEED PRODUCTION

In 2015 and 2016, canola fields used for seed production were also surveyed. There was a decline in pollen deposition with distance into the seed production fields in both 2015 and 2016. This indicates that honey bees likely play a larger role in pollen deposition in the seed fields than in the commodity fields, and that role is present despite the activity of leafcutter bees in all the study fields. A decline in seed yield was observed with distance from honey bee hives in 2015, indicating that there may be a pollination deficit at greater distances from the honey bee hives.

Pollinator efficacy and response were tested in 21 hybrid canola seed production fields in 2015, and 18 fields in 2016. Female leafcutter bees, which hold their pollen on hairs located on their abdomen, were the best at depositing pollen. They were more effective at pollen deposition than honey bees and even male leafcutter bees (who have much less substantial abdominal hair).

Canola yield at increasing distances from honey bee hives in seed production fields in 2015.
Source: Hoover et al. 2017



Another trial found that wild pollinators, which may not contribute directly to pollination due to a low presence, may still contribute to hybrid canola pollination by inducing more movement of managed pollinators between the male and female flowers.

In 2014 and 2015, the research found that singles (one honey bee brood chamber) could be included in hybrid canola pollination in addition to doubles, as long as a similar stocking rate of number of frames of bees per acre is met.

CONCLUSION

A number of pollinators are found in commodity canola fields, but the abundance and diversity varies regionally. Managed honey bees are a common pollinator, as are flies and bumble bees. There are benefits to the crop of having abundant pollinators, and ongoing research is determining in what contexts yield and seed quality benefit the most from the actions of pollinators.

Hybrid seed fields are highly dependent on pollinators for seed set, and careful pollination management will increase yield. Both abundance and diversity of pollinators will benefit seed yield.

Finally, canola is a good crop for honey bees, and both growers and beekeepers benefit from the relationship between bees and canola.

Bees are just one type of pollinator that can contribute to higher canola yields. Hoverflies like this one are common in western Canadian canola fields.

Credit: Alberta Agriculture and Forestry

COMPLETED PROJECTS

Second midge species identified

KEY RESULT: Through this study, a second, previously unknown *Contarinia* midge species was discovered in Western Canada. Further work is underway on this new species, but overall, midge damage at the four Saskatchewan study sites was extremely low over the three-year project.

PROJECT TITLE, PRINCIPAL INVESTIGATORS:
"Monitoring of swede midge populations in Saskatchewan and determining the impact of swede midge on different growth stages of canola," Julie Soroka and Owen Olfert, AAFC Saskatoon

FUNDING:
SaskCanola, CARP

Find all previous Science Editions online at **canoladigest.ca** and more on research discoveries at **canolaresearch.ca**.

The swede midge, *Contarinia nasturtii*, is a significant pest of brassica vegetable crops and canola in Eastern Canada. It was first discovered in Saskatchewan in 2007, and now threatens the Prairie canola industry. In Ontario, there are usually four generations annually but the number of generations in Western Canada is not yet known.

A three-year study led by AAFC's Julie Soroka and Owen Olfert was initiated in 2014 at four sites in north-eastern Saskatchewan. The project objectives were to investigate the susceptibility of canola at different growth stages to infestation by swede midge and to determine the influence of seeding date and insecticide seed treatments on levels of infestation. Researchers also wanted to assess the effectiveness of adult insect sampling techniques (emergence and pheromone traps) throughout the summer to determine the natural cycle of swede midge populations.

During the study, Soroka and Olfert's team discovered a second previously-unknown *Contarinia* midge species infesting canola. Because researchers were unable to differentiate the effects of each species, any assessed damage was considered to be caused by the *Contarinia* midge complex, including both swede midge and the new species. Two parasitoid species were also found to attack midge-infested flowers. If these parasitoids are attacking swede midge, this is the first report of parasitism in North America.

Overall, the research found that midge damage was extremely low over the three-year project. Early-seeded plots generally had higher injury ratings than late-seeded plots, but seed yield was not impacted. Seed treatment had no effect on midge damage and indicated either that these insecticides had dissipated and were no longer effective at the time of midge attack, or that midge damage was so low that no differences could be observed between the various treatments used in this study. Researchers would like to repeat the study in areas of high swede midge population levels such as those observed in Ontario.

Pheromone traps indicated extremely low or no swede midge population levels at the study sites. The newly identified *Contarinia* midge is not attracted to swede midge pheromone, but emergence traps provided some initial data on its lifecycle. This midge species has at least two generations on the Prairies, with only one appearing at the time of canola susceptibility during this study. Emergence traps also indicate that swede midge were not emerging from the soil at the four research sites. Future work is needed to clarify where swede midge is present on the Canadian Prairies.

Valuable new resource for cutworm management

Kevin Floate, research scientist with AAFC Lethbridge, has published his "Cutworm Pests of Crops on the Canadian Prairies: Identification and Management Field Guide." To download a PDF copy, go to **publications.gc.ca** and enter the title in the search box.

This guide will help producers identify and control cutworm pest species found on the Canadian Prairies. Included is general information on the biology and control of these pests followed by species-specific information. Also found in this guide are summaries of previous cutworm research, older control methods, and reasons why some control methods are no longer recommended. Information sources, many of which can be found online, are cited throughout the text. The historical context combined with current information helps identify knowledge gaps to direct future research.

Funding for preparation of this publication was provided by the Canola Council of Canada with contributions from Alberta Canola, SaskCanola and Manitoba Canola Growers in partnership with the Alberta Crop Industry Development Fund.

When straight-combining, hybrid choice matters more than header type

KEY RESULT: While this three-year study was designed to compare three straight-cut headers and a swathed check, results found that using a shatter-tolerant variety was much more important than header type for lowering the risk from straight-combining canola.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Canola direct-cut harvest system development," Nathan Gregg, PAMI

FUNDING: SaskCanola, WGRF, ADF

The three-year project (2014-16) compared three header types for straight-combining canola: rigid auger, draper and extendable knife. Treatments also included a swathed check. The test protocol involved harvesting strips in a randomized split-block design using two canola hybrids – standard InVigor L130 and shatter-resistant InVigor L140P – at two locations, Swift Current, Saskatchewan and Indian Head, Saskatchewan. Data collected included header loss, yield and seed quality.

RESULTS

Header loss. The rigid header had the highest losses overall, and was by far the worst for losses in the middle of the platform. Extendable knife and draper headers had lower losses in the middle of the platform, but all three straight-cut headers had fairly high losses at the crop dividers. In addition to comparing headers, the study also compared fixed, vertical knife and rotary knife dividers. Vertical knife and fixed dividers had lower losses than the rotary knife divider.

Yield. High variance in canola yield between site years was due, in most part, to hybrid choice and environmental conditions. No one header had the highest average yield in all situations, and the study found no consistent yield benefit for straight-cut versus swathed treatments.

At Swift Current, the shatter-resistant hybrid showed a 5 bu./ac. advantage when straight combined instead of swathed, but the standard or "typical" hybrid produced about the same yield when swathed or when straight combined using the extended knife or draper headers. Yields were lower for the rigid header. (See the table.)

At Indian Head, results for the shatter-resistant hybrid were about the same for all treatments, including swathing, but results for the standard hybrid were clearly better when swathed. A big reason for this was heavy winds that came after swathing but before straight combining at the Indian Head site in 2015 and 2016. This underlines the potential risk with standard varieties when they're left standing in adverse environmental conditions.

Seed quality. Generally favourable conditions at Indian Head for all three years resulted in desirable seed moisture, green content, seed weight and oil content for all treatments. Environmental challenges at Swift Current in 2015 and 2016 meant the crop was harvested tough and with higher green counts. When Swift Current results were averaged over the three years, swathed canola had lower seed moisture than straight-combined canola, but straight-combined canola had lower green seed counts, higher seed weight and higher oil content.

CONCLUSION

The primary header-choice objective of the study came to this conclusion: Extendable knife and draper headers are better than rigid headers when it comes to reducing header losses for straight-combining canola.

A key aspect of the project was the comparison between straight-cut and swathed canola, and it concluded that no one system will produce the greatest yield in every instance. Swathed canola yielded better in some site years; straight-combined canola yielded better in others.

By including the comparison between shatter-resistant and standard canola hybrids, this study came to perhaps its most important conclusion: Growing a shatter-resistant hybrid will mitigate risk under ideal and adverse environments, and is likely more significant than header choice for successful straight combining of canola. The final report adds: "As there is no defined standard for shatter resistance in canola, it is important to evaluate individual varieties and note that varieties labeled as shatter resistant or shatter tolerant may not be a direct substitute for the variety used in this study."

Average harvested yield, dockage, and dockage-adjusted yield over all three trial years.

Site	Variety	Header	Harvested Yield (Corrected to 10% moisture) (bu/ac)	Dockage	Dockage-Corrected Yield (bu/ac)
Swift Current	Typical	Draper	37.8	2.9	36.6
		Rigid	33.3	2.5	32.4
		Extended Knife	36.5	2.3	35.7
		Swathed	36.5	2.5	35.7
	Shatter-Resistant	Draper	42.7	2.8	41.5
		Rigid	42.7	2.4	41.7
		Extended Knife	42.6	2.9	40.3
		Swathed	37.4	2.4	36.6
Indian Head	Typical	Draper	50.8	1.0	50.3
		Rigid	50.2	0.9	49.7
		Extended Knife	51.6	0.9	51.2
		Swathed	57.6	1.3	57.1
	Shatter-Resistant	Draper	58.9	1.3	58.1
		Rigid	57.3	1.0	56.8
		Extended Knife	59.8	1.2	59.2
		Swathed	58.6	1.6	57.7

Harvest tips for weed seed management

KEY RESULT: If one goal at harvest is to reduce the weed seed bank, producers should focus their efforts on harvesting canola as soon as the crop is mature with the aid of chaff collectors or pulverization techniques. For the majority of producers not using these types of equipment, an alternative strategy might be to delay harvest to allow weed seeds to be shed where the mother plant grew. This will aid in keeping herbicide-resistant weeds such as wild buckwheat and cleavers in patches instead of spreading them throughout the field with the combine.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Can harvest weed seed management be used to control kochia, cleavers and wild buckwheat?" Steve Shirtliffe, University of Saskatchewan

FUNDING:
Alberta Canola, SaskCanola, Manitoba Canola Growers

In recent years herbicide-resistant weeds have become increasingly problematic in canola. Harvest weed seed management has emerged as a strategy to manage herbicide resistance and hard to kill weeds. The objective of this study was to evaluate the potential of harvest weed seed management techniques to manage seed production of cleavers, kochia and wild buckwheat in canola.

Two experiments were conducted in 2014, 2015 and 2016 in central Saskatchewan with the following objectives:

1. Determine the timing of seed shed in cleavers, kochia and wild buckwheat growing in canola.
2. Assess the efficacy of pre-harvest herbicides in reducing viable weed seed production in cleavers, kochia, and wild buckwheat.

For the first experiment, the timing of seed shed was sampled for both naturally-occurring weed populations and transplanted weeds. Since natural and transplanted weed populations differed in the timing, proportion and number of seeds shed, data from natural weed populations were taken to be most accurate.

HARVEST TIMING AND WEED SEED SHED

Weed seed shed response was linked to growing degree days (GDD). Seed shed of cleavers and wild buckwheat began at approximately 1,390 GDD, which coincided with the last week of August in 2015, and the third week of August in 2016. Kochia seed shed began at approximately 1,585 GDD, which coincided with the last week of September in 2015 and the second week of September in 2016.

If the canola crop was harvested in mid-September, approximately 73 per cent of cleavers, 65 per cent of wild buckwheat and 90 per cent of kochia seeds would remain on weed plants. If harvest was delayed to the end of September, approximately 54 per cent of cleavers, 32 per cent of wild buckwheat and 56 per cent of kochia seeds produced would remain on the weed plants.

Kochia, however, shed a much larger number of seeds than cleavers and wild buckwheat over the course of the experiment, averaging approximately 20 times more seed per plant. Therefore, at 1,390 GDD the three weed species had shed a similar number of seeds (≤55 seeds per plant), despite the fact that 99 per cent of seeds remained on kochia plants.

PRE-HARVEST HERBICIDES MAY NOT REDUCE WEED SEED BANK

In the second experiment, the efficacy of diquat and glyphosate in reducing weed seed production and viability was tested. Pre-harvest herbicides were applied at the recommended canola swathing stage of 60 per cent seed colour change on the main stem.

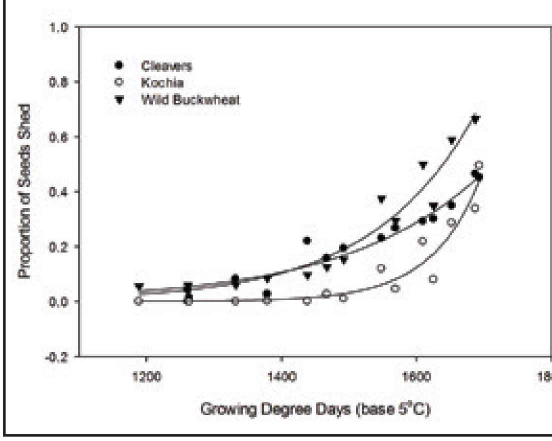
The results found that a pre-harvest herbicide application did not reduce the number of seeds shed by harvest time for cleavers, kochia or wild buckwheat. This suggests that herbicide application at canola swathing time is not early enough to prevent seed formation for the three weed species tested.

Viability of seeds produced in untreated plots and those treated with pre-harvest herbicides was tested in 2016, but did not differ between treatments. This is consistent with observations that seeds had already produced mature seed by the time of pre-harvest herbicide application.

For cleavers and kochia, there was a trend of higher seed shed by plants treated with diquat than the untreated control. This trend can likely be attributed to diquat accelerating dry-down of weeds that had already produced mature seeds, causing premature shattering.

The researchers concluded that farmers can save time and money by avoiding pre-harvest herbicide application as a weed-seed control measure, and focus instead on harvest timing. Harvesting as soon as the crop is mature with the aid of chaff collectors or pulverization (seed destructor) equipment can help collect and destroy the majority of seeds produced by these three weed species. Alternatively, if chaff collection or pulverization equipment is not used, delaying harvest will allow more weed seeds to be shed where the mother plant grew. This tends to keep herbicide-resistant weeds in patches instead of having the combine spread these seeds throughout the field. Delayed harvest will aid in containing wild buckwheat and cleavers seeds, but have limited efficacy in containing kochia seeds, due to the large number of seeds remaining on the plant in the fall, and its tumbling method of seed dispersal.

Figure 1: Seed shed of natural populations of cleavers, kochia, and wild buckwheat in response to thermal time. Data are averaged across three site-years in 2015 and 2016 in central Saskatchewan.



A storage plan for winter-to-summer weather changes

KEY RESULT: Leave it, aerate it or turn it? If canola in the bin is dry and cold coming out of winter, then just leave it be. But monitor the temperature, watching for any rapid increases. Have a plan to move the seed if an issue arises.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Determining best practices for summer storage of canola in Western Canada," Joy Agnew, Prairie Agricultural Machinery Institute (PAMI)

FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers, Government of Saskatchewan, GF2

Producers are storing increasingly more canola in bins during the summer months due in part to year-round delivery contracts, growth in markets and production, and increased bin capacity. Determining the best management practices to maintain proper temperature and moisture in the bins during the Prairies' hottest months is required to minimize the risk of spoilage, which could greatly impact total farm revenue.

This project was a continuation of Joy Agnew's 2014 study, which indicated that as outside temperatures go from cold in winter to warm in summer, leaving stored canola alone (as opposed to turning and aeration) resulted in the most stable conditions – provided the canola was cool and very dry (6 per cent). The objective of this project was to collect bin-scale data and to determine if canola with higher moisture content (9 per cent) should be managed differently when stored over the summer months or for longer periods of time.

The temperature profile (grain temperature and relative humidity) in three 3,500-bushel bins with 9 per cent canola was monitored from June to August in 2016. For monitoring, each bin had three in-grain sensors on the sunny side, three near the edge on the shady side, three down the centre and one in the headspace above the grain at the top of the bin.

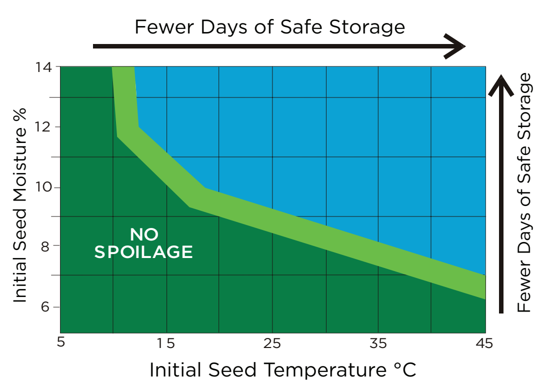
One bin was left alone, one bin was aerated to even out the temperature distribution, and one bin was turned to even out the temperature distribution. To "turn" the bins, the research team pulled out approximately 400 bushels and put it back on top. This amount fits in a tandem truck and is enough to funnel the top layer of grain into the core of the bin. Other bins of varying size were intermittently monitored throughout the summer.

In both years of the study, turning the bin at the beginning of June resulted in the lowest average bin temperature at the end of the monitoring period while aerating the grain in June resulted in the most uniform temperature distribution at the end of the monitoring period (refer to the table). However, both turning and aeration resulted in unstable conditions for a short period of time that may have resulted in condensation in the grain.

Similar to results in 2014, leaving the canola alone resulted in the most stable and favourable storage conditions throughout the summer months, provided the canola is dry (<10 per cent moisture content) and uniformly frozen (to <-5°C) going into the spring months.

Agnew and her team recommend that growers, no matter what storage system they choose, continually monitor temperature profiles to ensure canola remains in good condition throughout the storage period.

Recommended storage conditions for canola.
Source: White, 2013



Key temperature indicators at the end of testing for both trials (°C).

	Average Grain Temperature		Core Temperature		Max Grain Temperature		Highest Temperature Gradient*	
	July 2014	August 2016	July 2014	August 2016	July 2014	August 2016	July 2014	August 2016
Control	15.2	17.0	-1.9	4.0	23.1	22.5	25.0	18.5
Aerated	21.5	20.2	21.1	17.6	22.6	22.3	3.1	4.7
Turned	14.1	15.6	-3.0	9.5	18.9	21.5	21.9	12.0

*Temperature gradient is the difference between the lowest and highest sensor readings.

RESEARCH PAYS DIVIDENDS

The science behind the Canola Calculator

canolacalculator.ca will help farmers find plant densities and seeding rates that minimize risk and maximize profit potential. The tool depends largely on farmer-funded research.

BY DONNA FLEURY

The Canola Council of Canada launched the Canola Calculator in 2017 to help farmers find the most profitable balance between seeding rate and yield potential.

"In regular surveys with farmers, canola plant stand establishment always ranks very high on the list of production challenges," says Ian Epp, agronomy specialist with the Canola Council of Canada. "Seed represents one of the biggest costs for canola growers, so maximizing this upfront investment is important. The calculator was developed to help canola growers set an accurate seeding rate to achieve target plant stands and profitability goals and to manage risk."

The Canola Calculator has two components: target plant density calculator and seeding rate calculator.

"The plant density calculator has built in sliding scales to allow growers to be as specific as they like for various factors," says Epp. "For example, early-seeded crops may be at higher risk to frost, while late-seeded canola is probably a lot less, so growers can adjust for those differences. If there are a lot of flea beetles this fall on the fields you plan to grow canola next year, then perhaps insect pressure might be a bit higher. Or perhaps weeds are more of a problem in some fields. The calculator makes it easier to customize for specific factors."

Once the target density is calculated, the information can be saved to a 'My fields' folder online, printed or sent by email.

Next, go to the seeding rate calculator, which will already have the target plant density populated, and add thousand seed weight (TSW) and estimated survival. "For many farmers, estimating survival is probably the biggest factor they'll struggle with when using the calculator," explains Epp. "The industry average for canola across western Canada is 60 per cent survival, and although growers may think they are better than that, we rarely see fields any higher than 70 per cent."

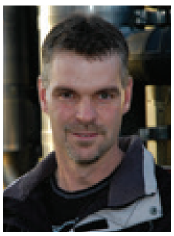
Unless growers have gone out and completed plant stand counts in their fields, using 60 per cent is recommended. "Fall is a great time to go out and actually do some plant counts in your fields to determine what your final plant density was at harvest," Epp says. "Start collecting your own data, so in the future you can customize the calculator to your specific management."

Epp encourages growers to think about their willingness to take risks and weigh all the factors before lowering seeding rates. For example, targeting lower plant stands like 4 or 5 plants per square foot is riskier than 6 to 10 plants per square foot. "If you reduce seeding rates to 4 plants and one is lost to flea beetles for example, that is a quarter of your crop gone. However, with 6 or 7 plants per square foot, potential for yield loss will be much less if you lose one plant per square foot."

Another risk with low plant stands can be weed or insect management applications that may not have been necessary with a more competitive crop stand, Epp adds.

The calculator project is a result of direct farmer investment through their canola organizations. "The outcomes make it pretty clear that it has been a good use of farmer money to improve farming practices," Epp says. "Some growers will be able to cut seeding rates and still have successful high-yielding canola crops. On the other hand, some growers will recognize that higher seeding rates are better for their operation to sustainably get that higher-yielding crop right from the beginning."

*Left: A screen shot of the Seeding Rate Calculator at **canola calculator.ca** using Bernie McClean's 4.5-gram seed weight, 10 plants per square foot target and 80 per cent seed survival.*



"It takes a lot of background research, manpower, time and energy to get tools like the calculator into growers hands. This handy calculator is an example of a great extension tool that is available because of grower and industry investment dollars."

—Bernie McClean

BEHIND THE CALCULATOR

Recent research and crop surveys clearly identified the need for establishing seeding rates based on thousand seed weight (TSW) and target plant density. About half of western Canadian growers have crop densities less than recommended optimal levels, which increases risk for yield and quality losses. An online seeding rate calculator was recommended.

The calculator was developed and built based on several years of research data from various projects. Murray Hartman, provincial oilseed specialist with Alberta Agriculture and Forestry, recently updated his original plant population meta-analysis, which formed the foundation of the calculator.

"Although early seeding rates were developed based on research using a combination of open-pollinated and hybrid data, by the mid-2000s we started to separate the data as more hybrid research became available," explains Hartman. "Growers and agronomists were seeing more vigorous plant stands and better weed control, and began to question if lower plant stands would make sense. We updated the data and Steven Shirtliffe at the University of Saskatchewan conducted a meta-analysis of over 35 research projects in 2009. The project, funded by SaskCanola and Alberta Canola, showed that lower seeding rates and plant populations could be economical. However, we found sparse data for canola production using very low target plant stands, and over the next few years more projects focused on providing that information."

Hartman used all of the data from various seeding-rates studies for hybrids specifically to update his plant population analysis. He confirmed that the actual physical response of hybrids now is different from the previous response with open-pollinated canola. Also, because the price of hybrid seed is dramatically different, it needs to be treated as an economic input like nitrogen fertilizer. The economics are very different for seed at $1 per pound versus $15 per pound.

"This was the real driver behind the calculator. It helps growers achieve the best economic returns for their seed investment," says Hartman. "A minimum target density of 5 to 7 plants per square foot is still a reasonable target range. Some growers currently using higher seeding rates may be able to lower their rates without sacrificing yield or quality and without big economic impacts. However, going too low may sacrifice yield, and increase risk and quality issues. The majority of growers are already at the minimum of 4 to 5 plants per square foot, but a third of growers are less than that, which means they may be sacrificing yield and quality."

SaskCanola director Bernie McClean has tested and used the new Canola Calculator. He sees it as a very handy tool. "Going through the tool and reading the information and helpful hints provided is a good place to start," says McClean. "It works on your phone and it's easy to use and see the results. The TSW is key and can really affect the recommended seeding rate. I typically target closer to 10 plants per square foot because I am pushing the growing season frost-free length on my farm near Glaslyn. Higher plant counts reduce the amount of branching on the plants, thus reducing the time to maturity."

SEED-WEIGHT EFFECT

Last spring, McClean's canola seed lots varied from 3.86 to 4.5 grams per TSW. Using his target of 10 plants per square foot and the base 60 per cent average survival rate, the calculator's recommended seed rate is 6.2 lb./ac. for his 3.86-gram seed and 7.2 lb./ac. for his 4.5-gram seed.

"Although I knew TSW made a difference, it wasn't until I started using the calculator that I really realized how much of a difference," says McClean.

Because McClean switched to an independent opener hoe drill, he figures his survival rate is closer to 80 per cent. "To confirm this, I do actual plant counts in the fall after swathing," he says. "The actual survival rate has a serious impact on the financial wellbeing of an operation, so this is an important step."

Going back into the calculator, if he increases seed survival to 80 per cent, this lowers the seeding rate to 5.4 lb./ac. for his 4.5-gram seed.

McClean, who is also chair of the SaskCanola Research Committee, sees the calculator as a great example of grower payback from an investment into research and extension tools. The many research studies that formed the foundation of the calculator were supported and funded by Alberta Canola, SaskCanola and Manitoba Canola Growers. The calculator was developed and released with funding by the Canola Council of Canada.

"It takes a lot of background research, manpower, time and energy to get tools like the calculator into growers' hands," McClean says. "This handy calculator is an example of a great extension tool that is available because of grower and industry investment dollars."

—Donna Fleury is a professional agrologist and freelance agriculture/science writer based in Alberta.

Band N to reduce losses

With a change in machinery, Red River Valley farmer Brad Erb had to give up his time-of-seeding nitrogen banding. So he opted for the next best thing to reduce losses for his soil type: Fall banding.

BY JAY WHETTER

"We usually have lots of moisture and, importantly, lots of heat in the spring. That combination increases volatilization, which is why, for us, spring broadcast has huge potential for loss. Fall banding is way less risky in our soil type."

–Brad Erb

Nitrogen efficiency based on application time and placement.

Time and Method	Relative Values
Spring broadcast	100%
Spring banded	120%
Fall broadcast	80%
Fall banded	100%

Source: https://www.gov.mb.ca/agriculture/crops/soil-fertility/soil-fertility-guide/nitrogen.html#relative

When Brad Erb switched seeding tools, it forced a shift in his nitrogen application strategy. The farmer from Oak Bluff, Manitoba had been applying anhydrous ammonia at the time of seeding through the mid-row bander on his drill. Based on old and new research, he knows that spring banding applications are the best way to limit nitrogen losses. He also knows from experience that time-of-seeding is really the only spring banding option for his heavy Red River soils.

"With our clays, any spring field work done before seeding destroys the seed bed," he says.

But then Erb bought a new disc drill that did not have the mid-row banding option. And as a disc drill, he couldn't risk putting nitrogen down that narrow opening with the seed. So, he needed to add another pass for nitrogen.

At the same time Erb was making his decision, he was hosting nitrogen application trials for University of Manitoba researcher Mario Tenuta. The canola-grower-funded study was comparing canola yield results for surface application, shallow banding and deep banding of nitrogen at 100 per cent and 70 per cent of recommended rates. (Read the full summary on page 4.)

The study, which was confined to east-central Manitoba, confirmed that losses are much higher with fall surface applications and that shallow- or deep-banding is better than surface applications in the spring.

With the amount farmers spend on nitrogen, this information provides a good payback.

"I rely on this research and a lot of my own on-farm testing to make the right economic decisions," Erb says.

Recent studies such as Tenuta's are also important to provide modern context for older studies that have been driving decisions for decades.

With every nitrogen decision Erb makes, he thinks about the "relative efficiencies" table created in 1975 based on Al Ridley's "*Effect of nitrogen fertilizers, time and method of placement on yields of barley*." If spring broadcast is 100 per cent efficient, Ridley concluded that other options had relative efficiencies as follows: Fall broadcast 80 per cent, Fall band 100 per cent, Spring band 120 per cent.

In short, to get the most return from nitrogen, spring banding is the best option. Tenuta's canola research from 40 years later confirms that this is still true.

So how does Erb apply nitrogen if he can't band it at the time of seeding or before seeding?

Fall banding is his best compromise for timing, logistics and reduced losses, he says. He bands when soil temperature drops below 10°C so that soil microbial activity and resulting nitrogen loss is minimized. He adds that, for his farm, fall banding is better than spring broadcast – even if Ridley's relative efficiencies suggest they're about equal.

"Fall banding is way less risky in our soil type," Erb says. "We usually have lots of moisture and, importantly, lots of heat in the spring. That combination increases volatilization, which is why, for us, spring broadcast has huge potential for loss."

Given the amount canola farmers pay for their nitrogen input each year, the payback from research to quantify losses and to choose best practices for nitrogen-use efficiency can be many thousands of dollars per farm per year.

Clubroot resistance saves canola in central Alberta

Grower-funded research at the University of Alberta has helped CPS bring new clubroot-resistant (CR) canola hybrids to market. These and other sources of CR canola has kept the crop economically viable in clubroot-infested areas.

BY DONNA FLEURY

Clubroot resistance is a priority at the University of Alberta canola breeding program. Finding good clubroot-resistant (CR) genes is just the first step.

"Developing varieties with clubroot resistance is not about putting a single gene into a single plant," says Habibur Rahman, professor and canola breeder at the university. "It is a challenging process of developing a package of traits that includes disease resistance, high yields, yield stability and good agronomic and seed quality traits."

A collaboration between Rahman's lab and Crop Production Services (a subsidiary of Agrium Inc.) is making new hybrids with improved genetic resistance to clubroot available to farmers. The latest commercial variety to come out of this collaboration is PV 580 GC.

The first step was to screen and identify sources of disease resistance from related germplasm and other Brassica species. Rahman and his team used a CR gene from Mendel, which is a winter canola cultivar from Europe, and another gene from a distant rutabaga relative. Transfer of genes from an unadapted germplasm like rutabaga is a big challenge, Rahman says. When crossed to canola, it also brings along other undesired traits that must be removed at the same time as bringing in the desirable traits.

"From this breeding work, we developed several hybrid parent lines that included all of the desirable traits we were targeting, including clubroot resistance genes," explains Rahman. "These hybrid parent lines were provided to CPS, who added them to their breeding program to release hybrid cultivars with double clubroot resistance for growers."

Rahman's clubroot breeding program, which continues, is funded by Alberta Canola, the Canola Council of Canada, Agriculture and Agri-Food Canada, Alberta Crop Industry Development Fund (ACIDF) and Natural Sciences and Engineering Research Council (NSERC).

For CPS, the collaboration with Rahman's breeding work is an integral part of their commercial breeding program. "To stay on the leading edge of hybrid development, we cannot work on all of the traits ourselves, so using a divide-and-conquer approach allows us to make advancement much quicker," says C.P. (Andy) Andrahennadi, senior hybrid breeder with CPS. "Another benefit of our collaborations is that these traits are tested, evaluated and bred in Western Canada. Clubroot resistance is a good example of this approach where the clubroot genetics were developed at the University of Alberta, screened and tested in central Alberta in the heart of the clubroot disease region and commercial hybrids developed in Western Canada."

MORE HYBRIDS TO FOLLOW

Habibur Rahman is a professor and canola breeder at the University of Alberta. His grower-funded work on clubroot resistance has helped improve the resistance in commercial varieties.

Identifying a source of resistance involves screening hundreds of diverse Brassica lines against multiple pathotypes of the clubroot pathogen. If the resistance comes from a wild or distantly-related species, then it takes more time to work these traits into adaptable genetics. In a normal program, it can take four or five years from trait identification to the commercialization stage.

This process includes taking the university's clubroot-resistant "mother lines" and converting them to male-sterile lines for hybrid seed production. The hybrid step includes crossing these mother lines and CPS father parent lines, which are produced in South America in Chile over the winter.

"These hybrid lines come back to Canada every spring and are tested not only for yield, but also yield stability, vigour, maturity, lodging and dedicated screening trials for clubroot, blackleg and fusarium wilt resistance," says Andrahennadi. "These hybrids not only mean growers in clubroot-infested areas can continue to grow this crop, they also greatly reduce the development of galls and spore production that typically occurs on susceptible varieties, which further reduces the risk of spreading the disease."

The new hybrid PV 580 GC is resistant to multiple clubroot pathotypes, including the predominant pathotypes found in Alberta, as well as recently-identified pathotype 5x, which is virulent on CR canola varieties carrying only single-gene resistance. Andrahennadi says more CR hybrids from the program will soon follow.

Genetic resistance is one of the key tools that farmers can use in a multi-disciplined approach to disease management. "Over 30 per cent of the world's food is lost to perils such as diseases, drought and other factors, making it difficult for producers to fully realize yield potential in a commercial farm setting," explains Andrahennadi. "Therefore, hybrids with built-in levels of disease resistance to serious diseases like clubroot or blackleg are tremendously important for producers to be able to realize higher yield potential from their crops and maximize returns."

—Donna Fleury is a professional agrologist and freelance agriculture/science writer based in Alberta.

Insect thresholds drive profitable pest decisions

One bertha armyworm per square metre can reduce canola yield by 0.058 bu./ac. So, 17 of them per square metre will drop yields by around 1 bu./ac. This information helps growers assess the threat and spray only when numbers are sufficient to provide a return on investment. How do we know these thresholds? Research.

BY TARYN DICKSON

They vary from insect to insect, and they help canola growers decide if an insecticide application is necessary or not. What are they? Insect thresholds.

These economic thresholds are an important consideration every growing season. For farmers and agronomists, it's worth knowing where they came from and how they might change over time.

The "Holy Grail" of insect thresholds for canola and other oilseeds is the *Western Committee on Crop Pests Guide to Integrated Control of Insect Pests of Crops.* You can find it online at **westernforum.org** under "Control Guidelines". The guide is reviewed and updated annually. Manitoba Agriculture entomologist John Gavloski provided the 2017 update.

"The basic research behind a number of insects and their impact on the plant has stayed the same over time," Gavloski says. Hybrid varieties yield much higher now than varieties did decades ago, seeding rates have changed over time and the number of canola fields across the Prairies has grown dramatically, but the insects are still feeding the same way.

ECONOMIC OR NOMINAL

Whenever discussing insect thresholds, Gavloski cautions that the type of threshold must be clearly distinguished: nominal or economic. Many of the thresholds used are nominal thresholds, which are based on experience rather than research to quantify the impact of the insects on crops.

Examples of nominal thresholds are those for diamondback moth (DBM) and flea beetles. The current nominal threshold for DBM is around 20-30 larvae per square foot in plants with flowers and buds, but Gavloski suggests that research could make this threshold more precise and should be more crop-stage specific in order to make it more robust.

Examples of economic research-based thresholds are those for bertha armyworm (BAW) and lygus. True economic thresholds will vary with costs, so simply revising production costs will update the values.

An economic threshold doesn't mean all spray decisions will be straight-forward, though. For example, BAW has an economic threshold, but since their cycles are driven by weather (cold temperatures combined with little snow-cover can kill overwintering pupae) and natural enemies (predators, parasitoids and pathogens), their populations are influenced by more than just access to food and crop stage.

Another complication to consider is the multiple species of some pests, such as flea beetles which now have populations of crucifer, striped and hop species.

Find all previous Science Editions online at **canoladigest.ca** and more on research discoveries at **canolaresearch.ca**.

Lygus has a research-derived economic threshold: when flowering is complete, canola fields can experience yield loss of 0.1235 bu./ac. for each lygus bug per 10 sweeps. New research is seeing if this yield loss per lygus should be lowered for good growing conditions, which means growers and agronomists may want to check for threshold updates each year.

FARMER PERSPECTIVE

Katelyn Duncan, who farms with her sister, brother and dad near Regina, Saskatchewan, says they consider crop potential when making insect spray decisions.

"In addition to the damage that can be caused, we factor in yield potential," Duncan says. "If the field has higher yield potential, then we want to protect that and we'll be more likely to spray. We always look at the economics."

Fortunately, the industry is becoming much more familiar with thresholds and how to use them to make better decisions. Insect identification and threshold materials are available in print form and online from the provincial agriculture departments, life science companies, local retails and various organizations, including the CCC.

"Working with a qualified and trusted agronomist is important but isn't a complete replacement for scouting on your own farm," says Duncan, "especially when we see spray planes out on neighbouring canola fields. Then we definitely want to double-check the sample numbers and threshold values to make sure we're making the right decision."

INSECT MONITORING

Provincial governments, with help from CCC agronomy specialists, conduct annual insect surveys to provide a fairly comprehensive picture of insect populations in each region. The Prairie Pest Monitoring Network shares weekly updates on population predictions and relevant information (such as the wind trajectories that could be bringing up DBM populations) and the Alberta Insect Pest Monitoring Network has survey results, forecasts and real-time maps for specific pest insects.

Growers and agronomists can also get timely advice at **canolawatch.org**, and meet the experts at workshops and meetings such as the provincial crop diagnostic schools and the canoLAB and canolaPALOOZA events that the CCC puts on with Alberta Canola, SaskCanola and Manitoba Canola Growers.

Social media also makes the sharing of information and diagnosis of insect issues quicker and easier than ever, although users should always consider the source.

"A farmer can ask a question on Twitter and very quickly get an answer or be referred to a credible resource with the answer," Duncan explained. "It's pretty handy and incredible valuable for farmers to have a network of trusted sources at their finger tips."

INSECT RESEARCH CONTINUES

Research into insect monitoring and to update or create economic thresholds remains necessary. Hector Carcamo, research scientist at AAFC Lethbridge, is part of a team currently working to validate or redefine the 25 per cent damage threshold for flea beetles and to update those for lygus bugs in canola. This will be a great asset to canola farmers

SCOUTING SCHEDULE BY PLANT GROWTH STAGE

Pre-seed/Seedling	Seedling	Rosette	Budding	Flowering	Ripening
				Bertha armyworm m²	
	Cabbage root maggot				
		Cabbage seedpod weevil			
Cutworms					
	Diamondback moth				
Flea beetles					Flea beetles
		Grasshopper m²			
			Lygus bug		

*This schedule shows when to scout for each insect in canola. Symbols beside each insect name indicate how to scout. For more information on this table, download the Canola Insect Scouting Guide at **canolacouncil.org**.*

RESEARCH PAYS DIVIDENDS

DANNY DION | DONNELLY, ALBERTA

On our farm, Dion Brothers Ltd, which I run with my brother, we have made good use of a few Smoky Applied Research and Demonstration Association (SARDA) projects that have received grower-funding through Alberta Canola. Through these local fertility trials, we learned how far we can push modern hybrids for our climate. Knowledge gained through this research has helped us make better fertilizer-rate decisions, which have made a big difference to the bottom line for our farm. We also help SARDA with variety trials. We get to know how certain varieties will help with our harvest time management. By choosing a combination of early- and later-maturing varieties that are suited to our area, we can spread out our harvest and make better use of labour and machinery.

(especially with suspicions that current lygus economic thresholds are too low).

The pest-reducing impact from beneficial insects is also being researched. Although quantifying the effect that beneficial insects have on insect pest populations is very challenging, it would add value to thresholds once completed.

The bottom line with all of these thresholds is to help farmers realize that some insect feeding is acceptable, and that only when numbers or levels of damage reach a certain point will the time and cost to spray provide a payback.

—Taryn Dickson is resource manager for the Canola Council of Canada crop production and innovation team.

Test your thresholds knowledge

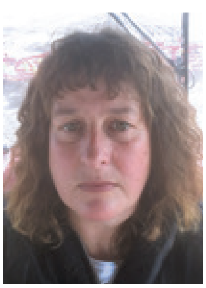
Thresholds for common canola insect pests

- **Alfalfa looper:** No thresholds. Use bertha armyworm levels for a guideline.
- **Aphids:** Nominal. Control if densities exceed an average of 25 aphids per 10 cm of shoot tip after flowering. Find this average from a sample of 20 or more shoots.
- **Bertha armyworm:** Economic. A loss in canola of 0.058 bu/acre for each larvae per square metre. Use the thresholds table from the bertha armyworm chapter at **canolaencyclopedia.ca**.
- **Cabbage seedpod weevil:** Nominal. Use a sweep net. The threshold is 3-4 adult weevils per 180° sweep.
- **Diamondback moth:** Nominal. 100-150 larvae per square metre in immature to flowering plants, and 200-300 per square metre in plants with flowers and pods. If larvae are feeding on seedlings, follow the flea beetle thresholds as a guide.
- **Flea beetles:** Nominal. If seed treatment is not providing enough protection, consider a foliar spray if average leaf area loss exceeds 25 per cent and flea beetles are still present and feeding.

  Flea beetles can return later in the season to feed on maturing canola plants but are rarely an economic concern.
- **Grasshoppers:** Nominal. 8-12 per square metre in canola.
- **Lygus:** Economic. At pod ripening, a loss of 0.0882 bu./ac. for each lygus bug per 10 sweeps (with a 38 cm diameter sweep net and a minimum of 15 samples per field). When flowering is complete, a loss of 0.1235 bu./ac. for each lygus bug per 10 sweeps. Use the thresholds table from the lygus chapter at **canolaencyclopedia.ca**.
- **Cutworm:** Nominal. Thresholds vary by species and by crop. Redbacked and pale western threshold for canola is 4-5 larvae per square metre.
- **Red turnip beetle:** No thresholds.
- **Root maggot:** No thresholds and no insecticides are registered for control of root maggots in canola.
- **Swede midge:** No thresholds for Western Canada, but research is underway.
- **Wireworm:** No thresholds for canola in Western Canada.

To assist you on your annual scouting schedule and method of scouting for each insect, download the CCC Insect Scouting Guide at **canolacouncil.org** and read the insect articles at **canolawatch.org**.

RESEARCH PAYS DIVIDENDS



TRACY POPP | SELKIRK, MANITOBA

Flea beetles have become a particular bad pest in our area. We had to reseed 300 acres in 2015 because flea beetles wiped them out. Everything looked fine in the field, but when we came back three or four days later, there was nothing left. Seed treatments are important, but we need more management tools. Grower-funded research led by Alejandro Costamagna at the University of Manitoba is looking at integrated approaches that include prediction models, true economic thresholds and landscape effects – all of which should improve our flea beetle management and improve canola profitability in the face of this major insect pest. I will also add that in my area, canola acres in general are under pressure from soybeans and corn. Going forward, canola growers will have to invest in whatever research we need to keep canola in the rotation.

Here are summaries for the remaining 10 ongoing studies funded through the $20 million *Growing Forward 2* (GF2) research agreement between the federal government and the Canola Council of Canada.

CCC GROWING FORWARD 2 **UPDATES**

Growing Forward 2
A federal-provincial-territorial initiative

PLANT ESTABLISHMENT

INVESTIGATING TOLERANCE OF CANOLA GENOTYPES TO HEAT AND DROUGHT STRESSES, AND ROOT TRAITS ESTIMATION BY ELECTRICAL CAPACITANCE

PRINCIPAL INVESTIGATOR: Bao-Luo Ma, AAFC Ottawa
PURPOSE: To better understand the physiological mechanisms of tolerance to heat and drought stresses in canola genotypes.
PROGRESS: Drip irrigation systems were shown to increase seed yield by 39 per cent, seed oil content by 4.3 per cent and root capacitance by 66 per cent as compared with the rain-fed practice in a drought-prone year (2016). Measurable differences were found between the genotypes under drought conditions, indicating the feasibility of utilizing root capacitance measurements to quantify canola tolerance to drought stress. A related study found that seed yield and root capacitance were both significantly higher with early planting dates. As well, root capacitance showed strong and positive relationships with seed yield and seed oil content, implying that the electrical capacitance measurements can be used to estimate root morphological traits and potentially predict canola seed yield and seed quality. In addition, an improved non-destructive method was developed for measuring canola root size, and a new method to assess root characteristics and crop lodging was also evaluated.

CANOLA SUSTAINABILITY - RISK MITIGATION

PRINCIPAL INVESTIGATOR: Neil Harker, AAFC Lacombe
PURPOSE: To determine if the risks of growing canola more frequently in rotations can be mitigated by inputs that are higher than normal (fertilizer, seed) or unusual practices (enhanced seed treatment or chaff removal).
PROGRESS: The greatest yields were recorded when canola was grown only once in three years at a normal fertility regime (a peas-wheat-canola rotation). The canola-wheat-canola rotation yielded similarly. While continuous canola with 50 per cent more fertilizer and 50 per cent more seed yielded similarly to the peas-wheat-canola rotation, extra fertilizer and seed costs would likely make the former treatment less economically viable and more risky from a weed, disease and insect pest point of view. Therefore the cheapest and most consistent method of achieving optimal canola yields is to ensure that there is diversity in the crop rotation sequence.

CANOLA ROTATION STUDIES

PRINCIPAL INVESTIGATOR: Claude Caldwell, Dalhousie University
PURPOSE: To gain a better understanding of how canola can fit into existing cropping systems in Eastern Canada, this four-year study was conducted at three locations in Nova Scotia, Ontario and Québec and was based on an established rotation experiment.
PROGRESS: Crop yields and plant height at harvest were significantly influenced by the crop sequence. Canola yields were greatest when grown after corn and lowest when grown canola on canola. Soybean and wheat yields were also greatest when grown after corn and lowest (for both) when grown after wheat. Although not significant, corn yielded highest when grown after soybean and lowest when grown after wheat.

FERTILITY MANAGEMENT

VARIABLE N FERTILITY MANAGEMENT OF CANOLA AT THE FIELD SCALE, BASED ON ANALYSIS OF YIELD MAPS AND SPATIAL AND STATISTICAL VARIABILITY OF SOIL TEST N AND P

PRINCIPAL INVESTIGATOR: Alan Moulin, AAFC Brandon
PURPOSE: To examine the impact of variable rate nitrogen fertility programs on canola yield in areas with consistently high production. It also investigates the economic return and efficiency of fertilizer use, the relationship between canola yield and the variability of canola yield and soil-test nitrogen and phosphorus, and the variability related to soil-test recommendations, among other factors.
PROGRESS: This study was originally designed for combined analysis of data from 24 sites over three growing seasons and was extended to include sites in the 2017 growing season as well. Preliminary results showed considerable variability in the soil and crop data collected from sites, significant differences in yield monitor data between farms, and significant contrasts between a

nitrogen rate of 0 and rates of 50, 100 and 150 per cent of soil-test recommendations for several farms in partition analysis. Preliminary findings from 2016 show that spring soil-test P averaged for all fields was similar to previous years, and showed a trend to higher P in lower-producing zones.

INTEGRATED PEST MANAGEMENT

CHARACTERIZATION AND DEVELOPMENT OF NEW RESISTANT SOURCES FOR SUSTAINABLE MANAGEMENT OF CLUBROOT IN CANOLA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon
PURPOSE: This project, which builds on previously identified clubroot resistance (CR) genotypes, discovers new CR genes with novel traits, develops markers closely linked to these CR genes (to assist CR breeding) and investigates resistance mechanisms by different CR genes for better deployment of these CR genes.
PROGRESS: In addition to publishing four peer-reviewed papers in 2016, the collaborative efforts of AAFC Saskatoon, University of Alberta and University of Manitoba carried out genetic mapping of additional CR *Brassica rapa* lines. This resulted in the discovery of two new CR genes that have promise against pathotype 5x and further work made it possible to successfully generate *B. napus* carrying both of the CR genes. Utilizing sequencing technology, researchers also figured out a way to transfer different clubroot resistance genes from *B. rapa* into canola through marker-assisted selection. CR genes at different locations on the chromosome may have similar resistance modes of actions and this study has proved the value of separating CR genes or gene combinations based on their modes of action against different pathotypes.

MANAGEMENT OF CLUBROOT IN A DYNAMIC ENVIRONMENT

Principal investigators: Sheau-Fang Hwang, Alberta Agriculture and Forestry, and Steven Strelkov, University of Alberta
PURPOSE: The aim is to develop effective and economical techniques to eradicate localized clubroot infestations using soil fumigants, to assess the impact of cropping rotations which include clubroot-resistant (CR) canola cultivars and to optimize practices for disinfecting agricultural and industrial equipment that has been contaminated with clubroot-infected plant material and/or soil containing spores.
PROGRESS: Vapam fumigant application was found to reduce clubroot severity at 40-80 mL/m2. Some residual toxicity to the plants was noted at higher dosage rates. Vapam treatment was most effective when sealed under plastic for 12 days, but sufficient ventilation time (1-2 weeks) must be allowed afterwards before seeding to avoid residual toxicity. Disease severity tended to decline when CR cultivars were rotated, but alternating non-hosts, resistant cultivars or fallow with susceptible cultivars did not reduce disease, nor did growing the same CR cultivar over repeated cycles. Although resistance breakdown is an ongoing challenge to clubroot management, differentiation between cultivars in the degree of resistance breakdown will provide opportunities for the study of how host and pathogen genetics interact.

CLUBROOT SURVEILLANCE AND EPIDEMIOLOGY

PRINCIPAL INVESTIGATOR: Stephen Strelkov, University of Alberta
PURPOSE: To utilize clubroot surveillance to track incidence and predict the spread of clubroot, identify potential issues, monitor populations for pathotype shifts, and evaluate clubroot resistance in fields, which can support all other clubroot-related research and management activities.
PROGRESS: The 2016 survey of 570 commercial canola crops in 40 counties and municipalities in central and southern Alberta revealed 68 new fields with clubroot (*Plasmodiophora brassicae* Woronin) infestation. Disease severity ranged from mild to severe, with an average index of disease of <10 per cent in 45 crops, 10-60 per cent in 20 crops, and >60 per cent in three crops. The three cases of severe clubroot were found in susceptible hybrids. The grand total of clubroot-infested fields confirmed in Alberta since surveys began in 2003 is now up to 2,443. While most of the 289 new cases were found on susceptible canola hybrids or hybrids of unknown resistance, 42 fields planted to clubroot-resistant hybrids had symptoms of the disease.

Completed GF2 studies

See page 8 in this issue for a full-page summary of Sheau-Fang Hwang's study, "The host-pathogen interaction of *Plasmodiophora brassicae* and canola."

Other completed studies have been summarized in past years. For example, Neil Harker's study, "Seed size and seeding rate effects on canola yield and quality" was featured in the 2016 Science Edition. Find all previous Science Editions online at **canoladigest.ca** and lots more at **canolaresearch.ca**.

This microscopic clubroot zoospore is about to infect a tiny canola rootlet. GF2 research projects are looking at various ways to stop this infection. This image from Azara Effect is from the Canola Council of Canada's video on the clubroot lifecycle. The video, produced with help from AAFC funding, explains how infection occurs and how to manage the disease. To watch the video, go to **canolacouncil.org** or **youtube.com** and search for "Clubroot of Canola Disease Cycle".

DEVELOPMENT OF PEST MANAGEMENT DECISION-MAKING PROTOCOLS FOR THE SWEDE MIDGE IN CANOLA

PRINCIPAL INVESTIGATOR: Rebecca H. Hallett, University of Guelph

PURPOSE: To evaluate efficacy and timing of insecticide applications, the use of pheromone-based action thresholds and to develop decision-making protocols for the timing of insecticide applications in order to reduce swede midge damage in spring canola.

PROGRESS: The application of regression analyses to the pooled data from trials conducted on grower fields (in 2013-2015) has helped to explain the relationship between swede midge pressure (represented by male midge counts in pheromone traps) and yield. These analyses, combined with results of previously reported lab studies, have led to the recognition that yield impacts to canola may result from lower swede midge pressure than previously thought, indicating that a lower action threshold may be needed for canola than has been evaluated to date.

THE ENVIRONMENTAL FOOTPRINT OF CANOLA AND CANOLA-BASED PRODUCTS

PRINCIPAL INVESTIGATOR: Vern Baron, AAFC Lacombe

PURPOSE: To estimate farm-gate canola carbon footprints in each soil zone and the greenhouse gas intensity for canola production using best management practices in a high-yielding, high-input region.

PROGRESS: Canola production had an economic advantage over barley, considering five-year average production costs and gross revenues produced net revenues of $302 per hectare for barley and $783 for canola. Carbon is gained during the growing season and lost outside of the growing season, during dormancy and at harvest (removed in the form of grain). Carbon yield in grain was greater in early-planted canola than late-planted canola. Carbon dioxide (CO_2) emissions from farming activities were largely from manufacturing farm inputs (78 per cent) and diesel fuel used in farm operations (19 per cent). Nitrous oxide emission was 51 per cent greater for early-planted canola than early planted barley due to higher amounts of N fertilizer used and higher contribution of N (from residue) to the soil for canola (vs barley). Therefore, the average carbon balance for all crops and planting dates was negative. The amount of carbon assimilated in net production by the crop environment offset the emissions from nitrous oxide and CO_2 from farming operations and activities but did not when the amount of carbon removed from fields in grain was accounted for.

Far right: Weather Innovations is using canopy weather monitoring and field observations to develop sclerotinia prediction models.

OPERATIONAL MODELS TO FORECAST CANOLA GROWTH STAGE, SCLEROTINIA RISK, AND YIELD IN WESTERN CANADA

PRINCIPAL INVESTIGATOR: Rishi Burlakoti, Weather Innovations

PURPOSE: To develop models and deploy forecasting tools for canola growth stage, sclerotinia stem rot risk and canola yield on a near real-time basis.

PROGRESS: Three years of small-plot trials and field-scale trials were utilized to create canola growth-stage predictions for short-, mid-, and long-season cultivars with accumulated physiological day (P-day) thresholds. Sclerotinia biology and disease knowledge combined with a previously developed sclerotinia stem rot (SSR) checklist made it possible to develop a SSR score card and model (with weather and agronomic parameters as input variables). The score card was validated using field data and the SSR model will be refined using field data to be collected during the 2017 cropping season. A custom webpage (**canoladst.ca**) is being used to collect and record field trial data as well as deploy and validate model prototypes. When completed, this SSR risk model will provide site-specific advisories for growth-stage predictions and sclerotinia stem rot risk in Manitoba, Saskatchewan and Alberta to help producers with fungicide treatment decisions and agronomic activities.

ONGOING PROJECTS

Canola producers support research-advancing management strategies and new tools for blackleg and sclerotinia in canola.

BLACKLEG AND SCLEROTINIA MANAGEMENT TOOLS FOR THE PRAIRIES

BY DONNA FLEURY

SaskCanola along with Alberta Canola and the Government of Canada through the *Growing Forward 2* AgriInnovation Program, have invested in alleviating the threat of blackleg and sclerotinia stem rot for canola farmers and advancing the development of new solutions. These challenging diseases are important concerns as they represent yield loss, economic impacts and potential trade issues. This research has helped pave the way for new tools and technology, advancements in disease-gene screening and new sources of disease-resistance genetics. Farmers benefit directly from the research by being able to understand and manage these diseases in their own fields, and maximizing productivity through access to new and improved disease-resistant canola cultivars.

ADVANCEMENTS IN FINDING NEW SOURCES OF RESISTANCE GENES FOR BLACKLEG

Current projects focused on new sources of resistance are making progress towards providing new resources and information for canola breeding programs to help improve blackleg resistance options for growers.

IMPROVING CANOLA RESISTANCE AGAINST BLACKLEG DISEASE THROUGH INCORPORATION OF NOVEL RESISTANCE GENES SOURCED FROM *B. NAPUS*, *B. RAPA* AND *B. OLERACEA*

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, AAFC Saskatoon

PURPOSE: To identify new major-resistance genes for blackleg disease through the phenotypic screening of 500 accessions of *Brassica napus*, *B. rapa* and *B. oleracea* with many different strains of *Leptosphaeria maculans*.

PROGRESS: New sources of resistance genes are needed to protect the commercial canola cultivars against constantly evolving blackleg pathogen populations. After screening over 1,100 *B. napus* and *B. rapa* accessions from the Plant Gene Resources of Canada (PGRC), researchers have generated the genetic profile of known resistance (R) genes against blackleg. Through a vigorous screening process including testing against up to an additional 40 isolates, researchers identified two *B. napus* lines and several *B. rapa* lines with potential novel R genes. Preliminary mapping supports the presence of a broad-spectrum novel R gene in one of the two *B. napus* accessions. This gene, located on the chromosome A1, behaves as a broad spectrum R gene as it shows resistance response to the majority of isolates being tested and will be highly valuable in controlling blackleg disease in Western Canada.

IDENTIFYING NOVEL RESISTANCE GENES FROM CANOLA RELATIVES AND DEVELOPING CANOLA GERMPLASM WITH MULTIPLE RESISTANCE GENES SOURCED FROM *B. NIGRA*, *B. JUNCEA*, AND *B. CARINATA*

PRINCIPAL INVESTIGATORS: Genyi Li and Dilantha Fernando, University of Manitoba

PURPOSE: To use cloned blackleg-resistance genes (1) to identify the effective resistance genes, (2) to monitor the changing of pathogen isolates in canola fields, (3) to guide pyramiding effective resistance genes in the development of canola cultivars, (4) to guide the deployment of canola cultivars with various blackleg-resistance genes; and (5) to identify novel blackleg-resistance genes in canola-relative species.

PROGRESS: Three years of testing under field conditions have resulted in good progress on the blackleg resistance. Testing results so far have shown that the previously identified horizontal R gene conferred good resistance to all field fungal isolates and performed well under severe blackleg disease pressure in the field. The results suggest that this resistance has excellent potential for blackleg management in Western Canada. Researchers are also making progress towards understanding the role and function of pathogenicity genes involved in disease using molecular tools such as ATMT and CRISPR. Currently, 80 isolates are undergoing phenotype characterization in terms of growth, sporulation, germination, attachment and pathogenicity, and new transformations are ongoing to generate a larger pool of isolates. This will determine the overall function of the gene products and the potential regulatory mechanism involved in *L. maculans* pathogenicity. All resistance gene-specific molecular markers and their effectiveness information will be provided to Canadian canola seed companies on a non-exclusive basis so they will be able to pyramid several resistance genes in newly released canola cultivars. This will ensure improved blackleg management options for Canadian canola producers.

GENOME-WIDE ASSOCIATION MAPPING OF QUANTITATIVE RESISTANCE AGAINST BLACKLEG IN *BRASSICA NAPUS*

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, AAFC Saskatoon

PURPOSE: (1) To identify tightly-associated genetic markers for controlling adult plant resistance to blackleg; and (2) to define the underlying genetic architecture of this durable resistance to blackleg in *B. napus*.

PROGRESS: Researchers have screened and tested several Brassica accessions for adult plant resistance (APR) against blackleg disease primarily at the blackleg field nurseries. A growth chamber based assay was developed that allows the test to be conducted under a controlled environment in a shorter time frame of two to three months compared to nearly six months in western Canadian conditions. Through an intensive screening process and pathology testing, the profile of APR against blackleg disease has been determined for 200 spring type *B. napus* accessions and the presence of quantitative resistance in 58 lines confirmed. These 58 lines, along with equal number of susceptible lines, have formed the association mapping population. As the next step, the position of the APR genes will be determined and markers linked to APR genes will be developed. Phenotyping and genotyping of individual lines of this population is in progress. *B. napus* lines with APR and molecular markers will serve as resources for breeding quantitative resistance, which is race non-specific and therefore more durable against the evolving pathogen races.

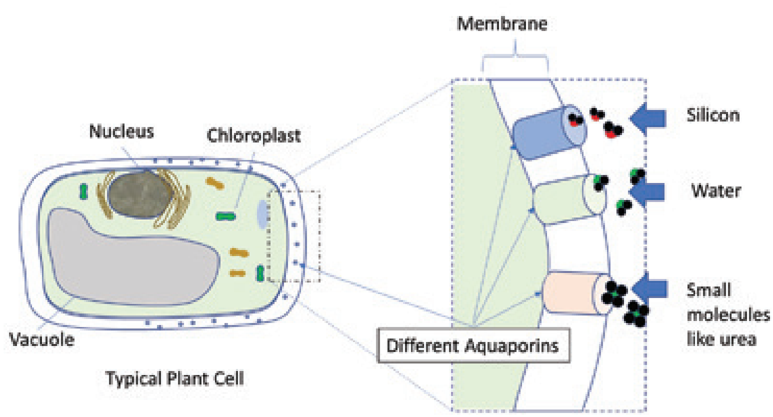
Richard Bélanger and his team are evaluating the potential role of aquaporins during biotic stress conditions in blackleg-resistant and -susceptible genotypes, including the induction of disease immunity pathways. Aquaporins are pore forming proteins that facilitate transport of water and many other small molecules like urea, silicon, boron, hydrogen peroxide and even carbon dioxide, in and out of the cell.

TRANSCRIPTOMIC ANALYSIS OF THE *LEPTOSPHAERIA MACULANS* (BLACKLEG-CANOLA) INTERACTION TO IDENTIFY RESISTANCE GENES IN CANOLA AND AVIRULENCE FACTORS IN *L. MACULANS*

PRINCIPAL INVESTIGATOR: Richard Bélanger, Laval University

PURPOSE: (1) To identify effectors and evaluate the comparative transcriptomic response of susceptible and resistant canola lines to virulent isolates of *Leptosphaeria maculans* (blackleg); and (2) to identify specific resistant genes in canola involved in the expression of an incompatible interaction with *L. maculans*.

PROGRESS: Researchers performed a transcriptomic analysis of resistant and susceptible *B. napus* genotypes infected with *L. maculans* to investigate the defense responses and provide a basis to understand molecular mechanism involved in blackleg disease development in canola. The transcriptome sequence for canola and *L. maculans* has been completed. (The transcriptome is a measure of the expression of all genes in a cell or tissues of any given organism under a particular condition.) Comparisons between the compatible and incompatible interactions led to the identification of 28 effector proteins suggesting a role in the establishment and maintenance of biotrophy. These included all known avirulence (Avr) genes along with eight newly characterized effectors. Another 15 effector proteins were exclusively expressed during the necrotrophic phase of the fungus, which supports the concept that *L. maculans* has a separate and distinct arsenal contributing to each phase. Researchers are also evaluating the potential role of aquaporins (AQPs) during biotic stress conditions in resistant and susceptible genotypes, including the induction of disease immunity pathways. Aquaporins are pore-forming proteins that facilitate transport of water and many other small molecules like urea, silicon, boron, hydrogen peroxide and even carbon dioxide, in and out of the cell. Genome-wide identification performed in seven Brassicaceae species revealed a total of 380 AQPs. The identification, classification, evolution and functional regulation of AQPs performed in the present study will be helpful for enhancing the understanding of AQPs and for the development of more sustainable stress-tolerant crops.



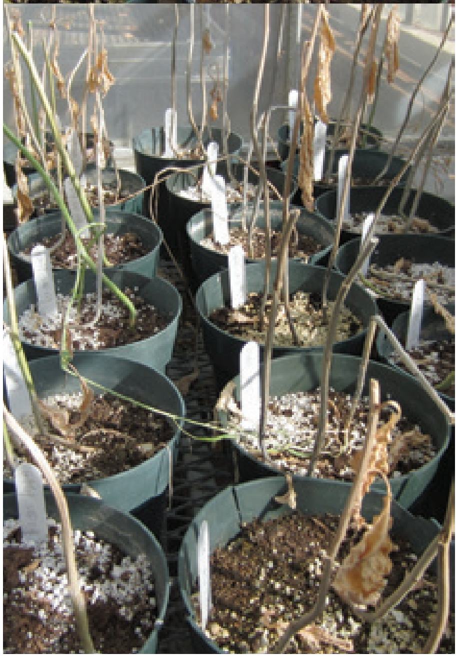
MONITORING BLACKLEG PATHOGENS AND PROGRESS ON RESISTANCE LABELLING

Research projects are focused on understanding and monitoring pathogen races and populations across the Prairie provinces in farmers' fields. In addition, they have led to the development of a new blackleg R-gene labeling system which will provide growers with another tool to manage blackleg on their farms.

DURABLE BLACKLEG RESISTANCE STEWARDSHIP THROUGH KNOWLEDGE OF BLACKLEG PATHOGEN POPULATION, RESISTANCE GENES AND CROP SEQUENCE TOWARDS THE DEVELOPMENT OF A CULTIVAR ROTATION PROGRAM IN THE PRAIRIE PROVINCES

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba
PURPOSE: To analyze avirulence (*Avr*) gene diversity and frequency of different Avr genes in different farms.
PROGRESS: Researchers continue making progress with additional findings to support the R-gene management strategy for blackleg. The project is collecting information from 50 representative grower sites across Alberta, Saskatchewan, and Manitoba from fields that have had blackleg to various degrees. In 2016, profiling *Avr* in *L. maculans* isolates collected from these fields generally found high frequency of *AvrLm4*, *AvrLm7* and *AvrLm6* in the pathogen population, while *AvrLm2* was more variable than in other years. In contrast, *AvrLm1*, *AvrLm3* and *AvrLm9* were generally absent in the fields monitored in 2016, indicating that the R-genes *Rlm1* and *Rlm3* found in these canola varieties are no longer effective in certain areas. These differences in blackleg disease among fields may be due to non-specific resistance in these canola cultivars, crop rotation practices and weather conditions at these locations. Researchers also developed a new protocol to quantitatively assess the colonization of canola tissue by the blackleg fungus, which may be used to rapidly determine non-specific resistance. The research information on the R-genes found in major commercial canola varieties and the *Avr* profile in the current pathogen population will provide growers and industry with additional tools for improved blackleg management. This work also supports the new initiative to label major R-genes for canola cultivars, helping growers to more effectively manage blackleg on their farms.

Right: Resistant plants (top). Susceptible plants (bottom).



RESEARCH PAYS DIVIDENDS

JANEL DELAGE | INDIAN HEAD, SASKATCHEWAN

I am a director with Indian Head Agricultural Research Foundation (IHARF) and I can think of one recent grower-funded IHARF study on seed-placed phosphorus (P) rates that has made a huge difference for our farm. We had been applying 20-25 lb./ac. of seed-placed phosphate, but with our yields, we knew we were quickly headed toward a serious P deficit in our soils. New IHARF research found that, in our heavier soils, we could apply 45 lb./ac. in the canola seed row without any evident increase in seedling loss. Being able to apply rates that match removal is a massive benefit for our soil P management. From a farmer's perspective, it's great to see these old recommendations revisited to make them pertinent for today. As a note of caution, I will emphasize that these rates work for our heavier, more-moist soils. This may not be a safe rate for all farms.

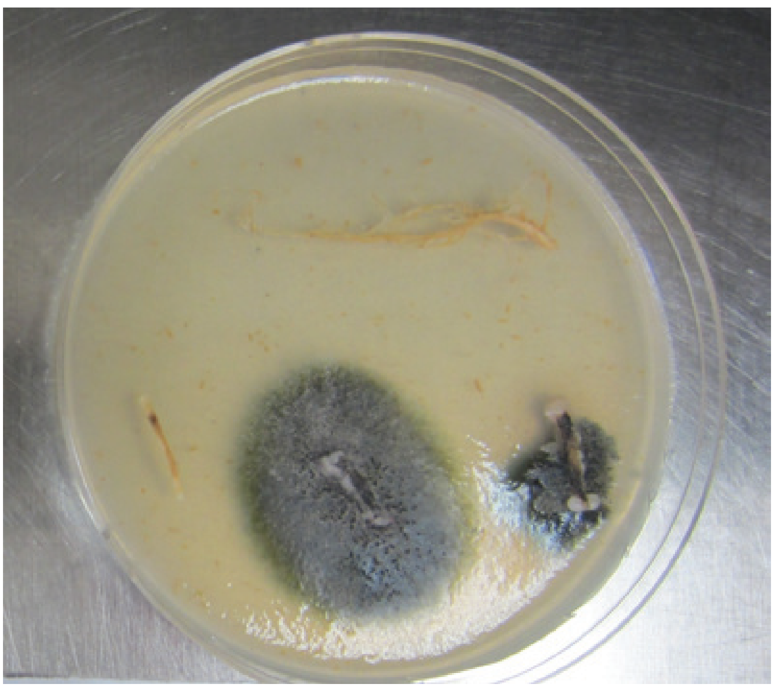
INVESTIGATING THE RESISTANCE (R-GENE) DURABILITY OF CANOLA CULTIVARS AND EMERGENCE OF VIRULENT BLACKLEG ISOLATES IN FARMERS' FIELDS

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba

PURPOSE: (1) To assess which cultivar resistance genes are most durable to disease pressure and make recommendations on when and how often to rotate cultivars studied; and (2) to examine the potential of emergence of virulent isolates when a new cultivar without corresponding resistance is introduced.

PROGRESS: Researchers are continuing to make progress on a method to assess the durability of any new blackleg R-genes or stacked R-gene combinations that may be made available to growers. The study is based on using the common canola-wheat two-year rotation. For the first study objective, plots of isogenic lines (ILs) carrying different single resistance genes (R-gene) were established and inoculated with 10-per-cent-virulent isolates to the corresponding R-gene. In subsequent years, the proportion of virulent isolates was measured. For the second objective, ILs carrying different R-genes were seeded and inoculated with 100-per-cent-avirulence (*Avr*) isolates to the corresponding R-gene. A patch of a susceptible line is used to maintain disease pressure. The plots are monitored to record if and when virulent isolates emerge, the number of generations required to produce virulent offspring, and to compare results between the different R-gene lines. At the end of the four-year project, the results will provide benefits to both growers and breeders. For growers this will result in recommendations of when to use different blackleg-resistant varieties based on their R-gene durability and the nature of emergence of new races.

Blackleg Fungal culture from three-week-old plants.



NEW TECHNOLOGY AND TOOLS FOR BLACKLEG MANAGEMENT IN THE FIELD

Researchers are making significant advancements in the development of tools, guidelines, and recommendations to help industry and farmers understand and manage blackleg disease in their canola rotations. A new blackleg yield-loss model helps farmers and industry quantify the economic impact of this serious disease.

RAPID FIELD DIAGNOSTICS OF THE BLACKLEG PATHOGEN RACES THROUGH THE IDENTIFICATION OF PATHOGEN AVIRULENCE (AVR) GENES AND THE DEVELOPMENT OF AVR-SPECIFIC MARKERS

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, AAFC Saskatoon

PURPOSE: To develop molecular markers as an efficient tool for genotyping and monitoring *L. maculans* populations in canola fields across Western Canada.

PROGRESS: Researchers have established a database of *L. maculans* genome sequences and developed PCR-based KASP markers. These markers have been extensively tested against close to 200 *L. maculans* isolates collected from canola fields across Western Canada. The markers have proven to be a highly accurate, high-throughput and cost-effective tool for determining the blackleg profile in farmers' fields. These KASP markers and protocol have been shared with the industry and a test has been planned in co-ordination with SaskCanola and the Canola Council of Canada to make this tool available to canola farmers by helping diagnostic labs adopt the methodology. By knowing the genotype of blackleg isolates, farmers will be able to choose the right canola varieties with resistance gene(s) against isolates present in their field. This will be a significant contribution to blackleg management for farmers.

DEVELOPMENT OF A BLACKLEG YIELD-LOSS MODEL AND ASSESSMENT OF FUNGICIDE RESISTANCE IN WESTERN CANADIAN POPULATIONS OF *LEPTOSPHAERIA MACULANS*

PRINCIPAL INVESTIGATOR: Stephen Strelkov, University of Alberta

PURPOSE: (1) To develop a yield-loss model to relate the severity of blackleg on canola with the corresponding yield losses; and (2) to evaluate representative populations of *L. maculans* from western Canada for the occurrence of fungicide resistance.

PROGRESS: This study is complete. Please read the summary on page 6.

Sclerotinia infection in canola.

ADVANCING SCLEROTINIA RESISTANCE IN CANOLA

Researchers have made significant advancements towards developing canola cultivars with true sclerotinia resistance a reality in the near future. Progress and development of new protocols, genome sequencing and screening are helping industry and farmers improve management of this disease in canola.

CHARACTERIZATION OF DEFENSE GENES UNDERLYING QUANTITATIVE RESISTANCE LOCI (QRL) TO SCLEROTINIA STEM ROT IN ASIAN *BRASSICA NAPUS* AND TRANSFER OF RESISTANCE TO CANADIAN SPRING-TYPE CANOLA

PRINCIPAL INVESTIGATOR: Lone Buchwaldt, AAFC Saskatoon

PURPOSE: (1) To identify molecular markers linked to sclerotinia resistance and identification of underlying defense genes; and (2) to transfer sclerotinia resistance to elite open-pollinated spring-type canola.

PROGRESS: Although sclerotinia resistance is a very rare trait, researchers have been able to generate *B. napus* lines with high levels of sclerotinia resistance. Canola breeders are interested in developing new canola varieties with sclerotinia resistance and some have requested seed of the resistant lines, molecular markers linked to the resistant trait, and sclerotinia isolates for screening of breeding lines. These lines will enable plant breeders to develop canola varieties with a high level of sclerotinia resistance, which will reduce the need for fungicide application, resulting in economic benefit to growers and also safeguarding growers, consumers and the environment. Researchers have also developed a stem-test protocol for testing canola for resistance to *S. sclerotiorum*. In 2016, after five years of evaluation by nine collaborators, the protocol was approved by the Western Canada Canola/Rapeseed Recommending Committee (WCC/RRC) as a standard for assessing sclerotinia resistance of lines submitted to co-op tests. Canola breeders and an increasing number of scientists in other countries including Australia and India are also using this stem test protocol. By the end of the project, researchers expect that the first canola lines with improved sclerotinia resistance from the program will be available for licensing. This resistance is expected to be long lasting, since it relies on several defense genes that are not easily overcome by changes in the pathogen population.

RESISTANCE TO *SCLEROTINIA SCLEROTIORUM* NECROSIS-INDUCING PROTEINS IN CANOLA

PRINCIPAL INVESTIGATOR: Dwayne Hegedus, AAFC Saskatoon

PURPOSE: (1) To identify proteins secreted by *S. sclerotiorum* that cause or contribute to necrosis; and (2) to develop a method to screen *B. napus* lines for resistance to their effects.

PROGRESS: In this project, several new *S. sclerotiorum* proteins, which cause the necrotic lesions associated with stem rot disease, were discovered. The proteins are now under study and tools are being developed to screen collections of *B. napus* lines for resistance to their effects. This project has greatly improved the understanding of *S. sclerotiorum* disease as the researchers catalogued for the first time the entire suite of genes deployed during each stage of the infection on canola. This project also contributed to an international consortium of Australian, U.S., European and Canadian researchers to sequence the *S. sclerotiorum* genome, which was published and deposited in a public database. A new international consortium is now comparing the genomes of *S. sclerotiorum* isolates from around the world to provide information on virulence and crop specificity. SaskCanola's investment in this project has been greatly amplified as it permitted participation in these international initiatives and is leveraging access to information, plant collections and tools that will ultimately lead to the development of new stem rot-resistant varieties for Canadian producers.

Results for these 12 projects will be posted on the SaskCanola website **saskcanola.com** as they come in. Some of the results will be featured this year at CanolaWeek, December 5-7 in Saskatoon. SaskCanola's website will have registration details. All final reports are likely due end of April 2018.

—Donna Fleury is a professional agrologist and freelance agriculture/science writer based in Alberta.

Canola growers across the Prairies fund dozens of research projects with their levy payments to the Saskatchewan Canola Development Commission, Alberta Canola Producers Commission and Manitoba Canola Growers Association. Many of those projects are funded through their joint Canola Agronomic Research Program (CARP), which has been going for almost 30 years. Other projects are funded through arrangements with other organizations listed in these summaries. Here are short descriptions and updates for ongoing projects directly funded by provincial canola grower organizations. **See page 2 for an explanation of all abbreviations.**

MORE GROWER-FUNDED RESEARCH PROJECTS

PLANT ESTABLISHMENT

COMPACTION IMPACTS ON CANOLA ESTABLISHMENT

PRINCIPAL INVESTIGATOR: Curtis Cavers, AAFC Portage la Prairie

FUNDING: Manitoba Canola Growers

PURPOSE: The objective is to determine how to manage canola stands under compacted soils and/or excess moisture conditions for best performance. This study examines the differences in soil strength (compaction) and canola stands under four tillage treatments of varying depths and intensities: vertical tillage; conventional tillage; subsoiled and raised bed/controlled traffic agronomy. Trials are duplicated under two different moisture regimes: dryland (rain-fed) conditions and irrigated to simulate wet (excess) moisture conditions.

PROGRESS: One trial was set up at an AAFC site at Portage la Prairie, Manitoba, in 2017, with data to be collected and analyzed. Two additional trials will be conducted at the same site in 2018.

TO GERMINATE OR NOT TO GERMINATE? TOWARDS UNDERSTANDING THE ROLE DORMANCY PLAYS IN CANOLA SEED VIGOUR, SEEDLING VIGOUR AND STAND ESTABLISHMENT

LEAD RESEARCHER: Sally Vail, AAFC Saskatoon

FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers, AIP

PURPOSE: This project is investigating the inter-relatedness of the potential for different forms of dormancy, seed biology characteristics and seedling vigour traits across a diverse panel of *Brassica napus* lines. It will also investigate the effect of the growing environment for parent seed and source-seed processing on enhancing or diminishing dormancy potential of canola seed. Results from this project will guide plant breeding approaches to ultimately reduce the secondary or inducible dormancy potential of canola.

PROGRESS: A wide range of secondary dormancy potential has been identified across the diverse panel of lines in seed harvested from multiple contrasting environments. The role environment plays in primary and secondary dormancy potential is shown to affect a subset of lines. There are high- and low-dormancy potential lines that are consistent across parent-seed-growing environments. Seed vigour metrics for lines and seedlots are being explored and preliminary results suggest seed vigour is not associated with secondary dormancy potential. Protein and seed fibre content appear to be moderately associated with dormancy potential and associations with additional seed quality traits continue to be assessed. Characterization of lines for propensity to germinate within the ripening pod is ongoing, and values will be compared to dormancy potential values. We are also working with hybrid-seed production partners to survey secondary dormancy potential within current commercial seedlots.

Right: Farming Smarter seeds its planter study plots, which so far shows a yield advantage for planters with 12" spacing versus an air seeder.

DEVELOPING CANOLA AGRONOMY WITH PRECISION PLANTERS

PRINCIPAL INVESTIGATOR: Ken Coles, Farming Smarter

FUNDING: Alberta Canola, Manitoba Canola Growers, Farming Smarter

PURPOSE: Precision planters provide superior depth control and seed distribution over conventional seeders, and thus have the potential to improve the proportion, uniformity and rapidity of canola emergence. This study hopes to explore optimum row spacing and seed-safe rates with in-row liquid phosphorus fertilizer.

PROGRESS: Four dryland and two irrigated trials were completed in southern Alberta during the 2016 and 2017 growing seasons. Results to date show a significant improvement in emergence using the planters. A yield advantage is clear with the planter on 12-inch row spacing and a slight disadvantage on 20-inch spacing versus the air seeder equipped with Pillar Laser openers. There was no apparent injury associated with seed-placed liquid phosphorus up to 40 kg/ha of P_2O_5 where yields maxed out. This would suggest that canola yields are potentially limited by insufficient phosphorus.

FERTILITY MANAGEMENT

Right: In Dale Tomasiewicz's study, his team will see if analysis of canola sap can guide in-season nitrogen application decisions. As shown in the image, plant sap is easily pressed from canola leaf stalks.

EVALUATION OF SAP NITRATE FOR IN-SEASON ASSESSMENT OF CROP NITROGEN STATUS

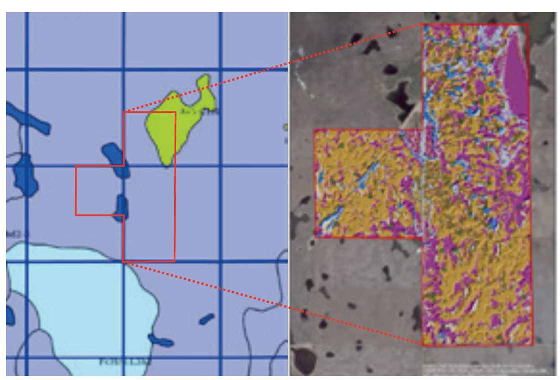
PRINCIPAL INVESTIGATOR: Dale Tomasiewicz, AAFC Outlook
FUNDING: SaskCanola
PURPOSE: The project adds sap nitrate analysis to the range of in-season tests to be evaluated for determining canola and wheat N status, enhancing an ADF-funded study of fertigation. Sap analysis can be conducted quickly on-farm, so may be a suitable diagnostic tool for guiding in-season N application decisions for topdressing or fertigation.
PROGRESS: The first of three field seasons was completed in 2017. Preliminary results showed concentrations of nitrate in the sap (from canola leaf petioles and wheat stem bases) to vary widely with N fertilization treatment. Sensitivity to N treatment effects was much greater at the later sampling stage (late June, a few days prior to stem elongation or heading) than at the earlier stage (mid-June, 5- to 6-leaf stage).

CROP RESPONSE TO FOLIAR-APPLIED PHOSPHORUS FERTILIZERS

PRINCIPAL INVESTIGATOR: Jeff Schoenau, University of Saskatchewan
FUNDING: SaskCanola, ADF, SPG, SWDC
PURPOSE: To determine the effect of foliar-applied phosphorus (P) on crop (canola, wheat, pea) response and residual soil phosphorus fertility in comparison to soil-applied phosphorus.
PROGRESS: The study began in spring of 2016 with four field-research sites selected across the Brown, Dark Brown and Black Soil Zones of Saskatchewan. Different treatments of foliar-applied orthophosphate solution were applied mid-season to canola, wheat and peas. Some treatments were in combination with granular monoammonium phosphate (11-52-0) applied with the seed. Plant samples were obtained for analysis before and after foliar P application. Application of foliar P resulted in significant increase in P concentration measured in plant tissue following application. In 2016, canola grain yield responded positively to seed-row applied 11-52-0 at one site. Overall in 2016, there was no apparent yield benefit from splitting application of P fertilizer between seed-row placed at time of seeding and foliar P at canopy closure for the three crops. Soil residual P levels were unaffected by P form and placement strategy. In controlled environment trials conducted in 2016 and 2017, similar results were obtained. Small-plot field trials were conducted again in 2017 at three sites in southern Saskatchewan. A field-scale trial with a commercial P-containing foliar product was also set up at one site in 2017.

ENHANCING CANOLA PRODUCTION WITH IMPROVED PHOSPHORUS FERTILIZER MANAGEMENT

PRINCIPAL INVESTIGATOR: Stewart Brandt, NARF
FUNDING: SaskCanola
PURPOSE: This research investigates whether current phosphorus (P) fertilizer recommendations are adequate for high-yielding cultivars and if all fertilizer P needs to be seed placed. It also examines if current recommendations regarding safe rates of P and sulphur (S) are suitable for typical knife or hoe openers in use today.
PROGRESS: In 2016, trials were conducted at three sites in Saskatchewan (Melfort, Scott and Indian Head). Preliminary results indicated that plant densities were unaffected by side-band P but declined with increasing P rates when seed placed. In addition, placing P with S in the seed row resulted in lower plant densities than when placed alone. At two of three sites, canola yield increased significantly with increasing P fertilizer. At one location, side-band P resulted in significantly higher yield than seed-placed, and tended to do the same at another location. The study was continued at the same three locations in 2017. Results are being compiled as yield data is available and the annual report will be submitted in early 2018.



Far right: To demonstrate the new Saskatchewan Soil Information System, the image on the left shows the study area mapped as polygons from the original soil survey maps. The one on the right shows the level of detail added through the digital soil mapping procedure.

ENHANCED SASKATCHEWAN SOIL DATA FOR SUSTAINABLE LAND MANAGEMENT

PRINCIPAL INVESTIGATOR: Angela Bedard-Haughn, University of Saskatchewan
FUNDING: SaskCanola, SPG, ADF
PURPOSE: This project aims to provide improved access to Saskatchewan soil information, both desktop and mobile. In addition, it will explore ways to enhance and utilize this soil information, including digital soil mapping at a resolution and scale useful for precision management and applications that allow producers to upload and integrate their own field-scale data to inform nutrient-management decisions.
PROGRESS: The beta version of the new Saskatchewan Soil Information System (SKSIS) has been distributed to a group of field testers from multiple sectors to get their feedback on its format and function. Demonstrations at the Agronomy Research Update and Soils and Crops were met with great enthusiasm. The audience was particularly excited to see drafts of refined soil maps for our test sites, which were developed using an optimized field sampling approach and a drone-collected digital elevation model. In the remaining few months of the project, we are working on finalizing SKSIS for official launch, incorporating any feedback received on the beta version, testing the potential for using the refined soil maps in understanding potential nutrient response across a field, and figuring out the next steps for the project in 2018 and beyond. An application has been submitted for an additional two years of funding to further enhance the site's functionality.

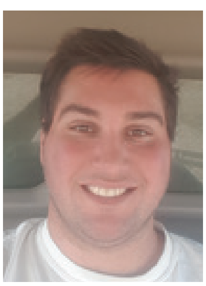
IMPACT OF SOURCE AND PLACEMENT OF NITROGEN AND SULPHUR FERTILIZERS ON CANOLA

PRINCIPAL INVESTIGATOR: Ramona Mohr, AAFC Brandon
FUNDING: SaskCanola
PURPOSE: Increasing farm size in western Canada has led some farmers to move back to less efficient broadcast nitrogen application in an effort to hasten spring seeding operations, thereby increasing the potential for the gaseous loss of nitrogen via volatilization. This study aims to identify fertilizer management practices that reduce the potential for volatilization losses, and improve fertilizer nitrogen use efficiency for canola.
PROGRESS: In 2017, field experiments were established on a calcareous and a non-calcareous soil near Brandon, Manitoba to assess the effect of various liquid and granular fertilizers, surface-applied or banded, on early-season N volatilization losses, crop yield and quality, and nutrient-use efficiency in canola. Fertilizer sources include urea, ammonium sulphate, UAN (with and without Agrotain or ATS), SuperU and urea impregnated with ammonium sulphate. Sample processing and analysis is underway currently.

IDENTIFYING THE MECHANISMS RESPONSIBLE FOR GREATER-THAN-EXPECTED RESIDUE-INDUCED N_2O EMISSIONS FROM CANOLA AND FLAX

PRINCIPAL INVESTIGATOR: Richard Farrell, University of Saskatchewan
FUNDING: SaskCanola, ADF
PURPOSE: Previous research found a higher potential for nitrous oxide (N_2O) emissions from decomposing canola (and flax) residues compared to wheat or pea residues. This project aims to identify the reasons for this and provide guidance for future studies to develop and test strategies to minimize N_2O emissions from oilseed residues and retain more residue-derived N in the soil for subsequent crop growth.
PROGRESS: Biochemical and isotopic characterization of the nitrogen-15 and carbon-13 labeled crop residues has been completed and soil microcosm studies with the residues are currently underway. These studies will allow us to determine whether N_2O emissions are influenced primarily by the physical or biochemical characteristics of the residues.

RESEARCH PAYS DIVIDENDS



ANTHONY ELIASON | OUTLOOK, SASKATCHEWAN

Canola Performance Trials, which are funded by the canola grower organizations and have one site at the nearby Irrigation Crop Diversification Corporation, provide me with very useful yield data – especially to show which varieties work best on irrigated land. I grow canola on both dryland and irrigated acres and, while yield differences are often pretty small on dryland, the same varieties can have five to 15 bu./ac. yield differences under irrigation. CPT results help me identify these highest-yielding varieties without having to do all the trial and error on my own farm. A gain of 15 bu./ac. just from picking the right variety can make a huge difference to my bottom line. SaskCanola-funded research is also helping to bring a new blackleg labelling system that identifies the R-gene source in each variety. This should improve my blackleg management and canola yields as this program rolls out.

Growers pay for third-party variety comparisons

Canola Performance Trials compare leading canola varieties in small-plot and field-scale trials. What growers get from this is independent, third-party data on new and familiar canola varieties – essential information in making variety choices.

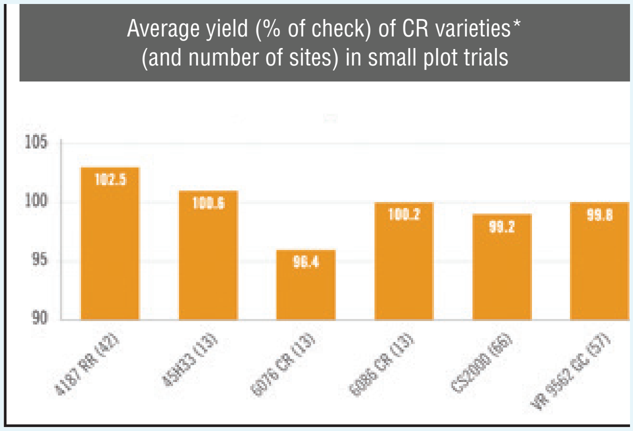
Alberta Canola, SaskCanola and the Manitoba Canola Growers Association fund the program, along with contributions from the British Columbia Grain Producers Association (BCGPA). The Canola Council of Canada (CCC) delivers the program on their behalf.

Online tool

Data from 2011 onward is loaded into the tool at **canolaperformancetrials.ca**. Use the filters to narrow the search by herbicide-tolerance (HT) system, season zone, days to maturity, yield and more. To compare clubroot-resistant (CR) varieties, choose 'show me all the data' and select the CR varieties. To compare two specific varieties, try the head-to-head comparison option. It only includes data from the two varieties that were grown at the same place and time (same site in the same year), so there are fewer data points but this provides a very high quality comparison. With each search, the program shows all the trial locations on the map. Click the flags to see results from a specific location.

New Canola Variety Selection Guide

The new 'Canola Variety Selection Guide: Featuring CPT Summary Data' is posted at **canolaperformancetrials.ca**. This booklet packages data from 2011 through 2016, laid out in a step-by-step format, providing useful information and data on different factors that could be considered when making seed decisions.



This comparison of yield results for clubroot-resistant (CR) varieties is just one of many CPT-driven data tables in the Canola Variety Selection Guide.

INTEGRATED PEST MANAGEMENT

DESIGN AND TESTING AN IN-FIELD REAL-TIME NANO-SENSOR DEVICE FOR PATHOGEN MONITORING IN CANOLA

PRINCIPAL INVESTIGATOR: Xiujie Li, InnoTech Alberta
FUNDING: Alberta Canola, ACIDF, InnoTech
PURPOSE: The long-term goal is to develop an in-field sensor for the detection of plant disease pathogen levels and transfer results to an electronic device in a real-time fashion. The purpose of this project is to design and make the device, and test it in the greenhouse and in the field.
PROGRESS: Signal transmission from the nano-biosensor to an electronic device has been achieved. The researchers are currently working on the modification of the nano-biosensor chip to improve the sensitivity to detect low level of *Sclerotinia sclerotiorum* spores.

IMPROVING SCLEROTINIA DISEASE CONTROL IN EDIBLE BEANS AND CANOLA

PRINCIPAL INVESTIGATOR: Michael Harding, AF
FUNDING: Alberta Canola, WGRF, APG
PURPOSE: The objectives were to look for synergistic relationships between foliar-applied micronutrients and fungicides when tank mixed, and to evaluate the efficacies of "resistance-priming" chemicals as seed treatments to improve sclerotinia management.
PROGRESS: The final report is in preparation. Synergistic combinations of trace elements and fungicides were determined in laboratory experiments using biofilm approach. Phase 1 involved screening for synergies between combinations of foliar-applied trace elements (Ag, B, Ca, Cu, Mn, Zn) and currently registered fungicides (boscalid, fluazinam, penthiopyrad, picoxystrobin, ciprodinil, fludioxonil). This screening used a novel, high-throughput biofilm reactor and standard method (ASTM E2799-11) to test 324 treatment combinations and identify the top 10 candidates for field testing. Phase 2 involved field testing of the top 10 most effective combinations. Two of the fungicides (fluazinam and cyprodinil) were very responsive to the addition of at least one of the trace elements tested. The results demonstrated that trace elements such as $CuSO_4$, $AgNO_3$ and $ZnSO_4$ can improve the efficacy of some fungicides versus *S. sclerotiorum* biofilms. The top-performing combinations were then tested in the field. In the replicated, small-plot field studies a few synergistic combinations appeared in some years, however none of the tank-mixed treatments were consistent in all years tested. One of the resistance-priming chemicals applied to seed has shown significant white mould reduction in three of eight years and significantly higher yields in five of eight years in dry bean. Unfortunately, the effect was not significant against stem rot in canola.

MONITORING THE RACE DYNAMICS OF *LEPTOSPHAERIA MACULANS* FOR EFFECTIVE DEPLOYMENT AND ROTATION OF RESISTANCE GENES FOR SUSTAINABLE MANAGEMENT OF BLACKLEG OF CANOLA IN WESTERN CANADA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
PURPOSE: Cultivar resistance plus extended crop rotation is the key to blackleg management. The deployment of effective resistance (R) genes in canola breeding depends on the knowledge of avirulence (*Avr*) genes in the pathogen population. This project will continue monitoring the blackleg pathogen population on the Prairies using diseased samples from a large number of commercial canola fields. The information will be useful to blackleg resistance breeding by deploying R-genes effective against the pathogen population and to the selection of canola cultivars carrying effective R-genes over canola crop regions.
PROGRESS: Field collection of blackleg samples has been completed for the 2017 crop year, with the help from provincial canola disease survey program coordinators. These samples are being processed and will be tested for the *Avr* profile shortly.

CHARACTERIZATION OF THE NEW STRAINS OF THE CLUBROOT PATHOGEN IN ALBERTA

PRINCIPAL INVESTIGATORS: Sheau-Fang Hwang, AF, Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, SaskCanola, ACIDF, WGRF
PURPOSE: Objectives are to monitor the spread of novel clubroot strains through surveys, assess the potential of novel pathotypes to reappear, characterize the pathotypes of clubroot that appear where resistance has broken down and multiply inoculum of novel pathotype(s) for resistance screening.
PROGRESS: In 2016, a survey of 570 commercial canola crops representing 40 counties and municipalities in Alberta revealed 68 new fields infested with clubroot. Another 221 new cases of the disease were found during surveillance by municipal and county personnel, for a total of 289 new clubroot-infested fields in 2016. Clubroot infestations have been confirmed in a grand total of 2,443 fields in Alberta since surveys for this disease commenced in 2003. All of the pathotype testing of the 2016 populations is now complete. In total, strains of *P. brassicae* capable of overcoming resistance were confirmed in 22 new fields (64 fields in total since 2013). Surveys have identified a total of 19 known pathotypes in Canada, 14 of which can break resistance in CR canola (and five of which are the original "old" ones).

TOWARD A STRATEGY FOR REDUCING THE SPORE DENSITY AND DISSEMINATION OF CLUBROOT OF CANOLA IN ALBERTA

PRINCIPAL INVESTIGATOR: Sheau-Fang Hwang, AF
FUNDING: Alberta Canola, ACIDF, WGRF
PURPOSE: The aim is to develop a better understanding of the distribution and dispersal of clubroot and to develop methods to eradicate or reduce newly established infestations within fields and on a regional basis.
PROGRESS: Experiments were conducted to evaluate the effect of metam sodium (Vapam) fumigant and application methods – including watering, soil surface covering and soil incorporation – on clubroot of canola. At higher rates (0.4-1.6 mL per litre of soil), metam sodium increased canola seedling emergence and plant health, and reduced root hair infection, gall weight and clubroot severity under greenhouse conditions. Metam sodium application improved subsequent plant growth and reduced clubroot severity, but land preparation and volume of water applied did not affect efficacy. The incorporation of metam sodium into the soil and plastic covering after application improved fumigant

RESEARCH PAYS DIVIDENDS

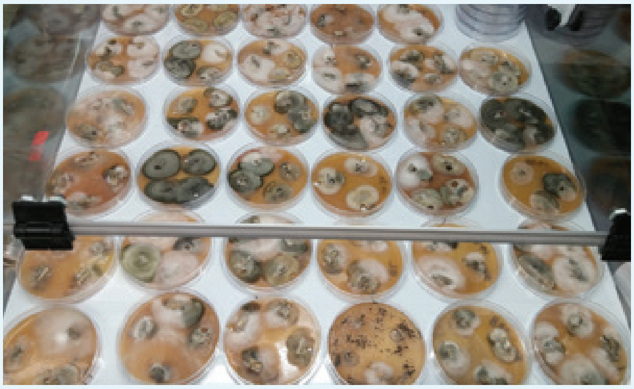
ART BIRD | ARROWWOOD, ALBERTA

My wife Dixie and I operate Prairie Rose Farms Ltd, and we recognize how crucial it is to have agronomic research that is relevant on the local and regional level. Our local research organization Farming Smarter provides me that information, which helps me keep up with emerging techniques, new crops and agronomy. Farming Smarter is continually doing trials with canola, whether the hail simulator project, seed population trials using a planter, or variable rate fertilizer. All of these trials have improved, or will improve, my understanding of canola agronomy and lead to a better bottom line on our farm. I'm especially interested in the canola agronomy and fertility trials, as we often seem to hit a ceiling with canola yields despite throwing a lot of inputs at it, whereas with wheat there seems to be a much more direct and predictable connection between inputs, yield, protein and quality. We had a dry year in our area in 2017 and, looking ahead to 2018, I'm reminded of how critical it is to grow the best crop we can while keeping a close eye on our expenses. We need agronomic research done on a regional level, which is what Farming Smarter does for us in Southern Alberta, thanks to funding provided from Alberta Canola, the Canola Council of Canada and various levels of government.

Manitoba's PSI Lab to ID more diseases, specific races

Manitoba's Pest Surveillance Initiative (PSI) Lab, a grower-led laboratory established to help growers better manage pest threats as they emerge, continues to grow its ability to move lab research off the bench and into growers' hands. The focus remains on 'what is in the environment' – helping Manitoba growers identify and track the pests in their region to more effectively manage risks to crop production on each farm.

While PSI was established with the support of the Manitoba Canola Growers in response to the growing threat of clubroot coming to Manitoba, 2017 saw significant expansion of its surveillance capacity through additional support from *Growing Forward 2*. PSI established both lab and field capacity to grow, identify and quantify a range of crop pathogens down to the race level. This can ensure that growers' pest management measures are effective for the type of pest in their field, and the specific race of that pest, which is important for managing pest resistance. Using blackleg of canola (*Leptosphaeria maculans*) as the model, PSI is developing procedures to rapidly identify the race of field-crop diseases found in the Manitoba environment.



The first step in determining blackleg race is to isolate single spores from field stubble.

Other crop diseases being evaluated include clubroot (*Plamodiophora brassicae*), fusarium head blight (*Fusarium spp*), cereal rusts (leaf, stem) and sclerotinia (*Sclerotinia sclerotiorum*).

PSI continues to share information with growers, extension personnel and industry at **mbpestlab.ca**.

Find all previous Science Editions online at **canoladigest.ca** and more on research discoveries at **canolaresearch.ca**.

efficacy. The study showed that soil fumigation with metam sodium can reduce clubroot severity and improve plant health in the subsequent canola crop. Clubroot infestations generally start with a few isolated plants, often close to the field entrance. Fumigation may have a role in the eradication of isolated areas of infestation, especially where the pathogen is not already endemic.

SUPPORTING CONTINUED DEVELOPMENT OF CLUBROOT-RESISTANT CANOLA AND EARLY DETECTION OF CLUBROOT OUTBREAKS

PRINCIPAL INVESTIGATOR: Michael Harding, AF
FUNDING: Alberta Canola, WGRF, ACIDF
PURPOSE: The objectives were to evaluate canola lines and cultivars for their various levels of resistance to *P. brassicae* (pathotype 5) and evaluate the efficacy of soil amendments and treatments for clubroot management. Additionally, the project enhanced clubroot surveillance in southern Alberta to rapidly identify any new introductions or outbreaks of clubroot south of Highway 1. The project also provided a backdrop and demonstrations for clubroot extension field days.
PROGRESS: The final report is in preparation. Since 2013, dozens of new canola lines were screened for clubroot resistance at this disease nursery and a number of them have shown strong resistance to pathotype 5. Soil amendments and chemical fumigants have demonstrated limited ability to provide significant or consistent control of clubroot in areas with high resting-spore populations. Clubroot surveillance has not discovered any new infestations south of Highway 1, however three new infestations just north of Highway 1 were recently reported. Clubroot field days drew 70-100 participants each year they were held.

GENOME-WIDE FUNCTIONAL ANALYSIS OF *PLASMODIOPHORA BRASSICAE* EFFECTORS AND THE MANAGEMENT OF CLUBROOT DISEASE

PRINCIPAL INVESTIGATORS:
Peta Bonham-Smith, Christopher Todd, Yangdou Wei, University of Saskatchewan
FUNDING: SaskCanola, ADF
PURPOSE: The objectives are to identify the *P. brassicae* proteins (effectors) and their host targets. Understanding these plant-pathogen protein interactions will provide the tools to unmask the pathogen within the cell, thereby allowing the plant defence system to fight the pathogen and control the clubroot disease. Identified *P. brassicae* effector proteins will be used as markers to track different *P. brassicae* pathotype populations in Prairie fields.
PROGRESS: This is a new study, but to date, six possible effector proteins have been identified that interfere with the plant defence system. Identification of more effector proteins is in progress, along with the identification of the plant proteins with which the effector proteins are interacting. Molecular and cellular mechanisms underlying *P. brassicae* effector activities and host responses are currently under investigation.

Right: Verticillium infection in canola can cause the outer layer of stems to peel. Under this peeled layer are often small black specks of verticillium microsclerotia.

Far right: The new undescribed Contarinia midge found attacking canola on the Prairies.

VERTICILLIUM LONGISPORUM IN MANITOBA: UNDERSTANDING THE PATHOGEN AND ESTABLISHING SURVEILLANCE CAPACITY

PRINCIPAL INVESTIGATOR: Mario Tenuta, University of Manitoba

FUNDING: Manitoba Canola Growers, Richardson International, MB Grain Hub, GF2 and WGRF

PURPOSE: In 2014, *Verticillium longisporum*, a fungal wilt pathogen of crucifers, was identified on canola in a field in Manitoba. The pathogen is one of the most important diseases of rapeseed in Europe, but little is known about the pathogen and its behaviour in Manitoba or the Prairies. This project will study the distribution and ability of the pathogen to disperse to soils on the finding farm, identify the hybrid line of the pathogen present and establish real-time PCR quantification protocols for the pathogen in soil. This prepares the province and industry for self-directed management of the pathogen.

PROGRESS: An M.Sc. student, Abhishek Agarwal, has a detailed survey of *V. longisporum* from fields at the farm where the pathogen was first identified. The pathogen is widespread on the farm, and while the vast majority of fields have low concentrations, a few fields have very high concentrations. This suggests the pathogen can move around fairly easily. The hybrid line found at the farm is that which is believed most aggressive to rapeseed. Preliminary analysis has not shown cropping history to be a factor in the distribution of the pathogen in the finding farm.

ENHANCED MODELLING OF SWEDE MIDGE POPULATION DYNAMICS IN NORTH AMERICA

PRINCIPAL INVESTIGATOR: Rebecca Hallett, University of Guelph

FUNDING: SaskCanola, Alberta Canola (CARP)

PURPOSE: The aim is to develop a complete population dynamics model for swede midge. The model will be used to explore differences among North American populations of swede midge and will try to predict the lag-time between first detection in an area and subsequent occurrence of economically-damaging populations.

PROGRESS: MSc student Jenny Liu has evaluated our previous forecasting model, MidgEmerge, to identify weaknesses that need improvement. The model will be re-developed with updated life cycle information in order to predict emergence more accurately. Experiments were undertaken this summer at University of Guelph and at AAFC Saskatoon to determine development and mortality rates of Ontario swede midges (larvae, pupae, adults) at different temperatures. Development rates and survival information will now be incorporated into MidgEmerge to improve its accuracy in predicting adult peaks of swede midge.

ASSESSING THE IMPACT OF *CONTARINIA SP.* ON CANOLA PRODUCTION ACROSS THE PRAIRIES

PRINCIPAL INVESTIGATORS: Meghan Vankosky and Boyd Mori, AAFC Saskatoon

FUNDING: SaskCanola, Alberta Canola

PURPOSE: A new, undescribed species of *Contarinia* midge was found attacking canola flowers in 2016. As this is an undescribed species, its life history, development, timing of adult emergence, distribution, and impact on canola crops needs to be determined. The purpose of this project is to conduct field and laboratory research to investigate this potential canola pest.

PROGRESS: Summer 2017 marked the first year of data collection for this project. The timing of adult midge emergence was monitored using emergence cages in northeastern Saskatchewan and canola plants were dissected weekly during the growing season to determine the timing of midge attack and midge development. To determine the distribution of this insect, a survey of canola fields in Alberta, Saskatchewan and Manitoba was completed in late July/early August. Midge larvae were found in all three provinces, and their identity is being confirmed in the laboratory using morphological and molecular techniques. Preliminary results from the 2017 field season will be made available at upcoming industry and academic meetings.

ULTIMATE CANOLA CHALLENGE

Ultimate Canola Challenge: Does more N pay?

The Ultimate Canola Challenge, brainchild of the Canola Council of Canada agronomy specialists, has the objective to challenge growers to obtain higher yields and profitability. What started out as small-plot research has evolved into on-farm testing of new products and practices so growers can test new ideas on their farm.

For 2016 and 2017, UCC trials on farms across Western Canada tested the return on investment for increasing the recommended nitrogen (N) rate by 25 per cent.

Results

Nitrogen trials were repeated in 2017 after a limited number of sites were harvested in 2016. Of 14 trials seeded in 2016, only six were harvested. Of those six, all saw increased yield with 25 per cent more N but only three were statistically significant. That is not enough to draw a conclusion on whether the extra N investment could pay off. Results for 2017, when collected and analyzed, will be posted at **ultimatecanolachallenge.ca**.

How to generate good data

UCC nitrogen trials follow these guiding principles for good data generation:

- Increase only nitrogen (N) rates, not other nutrient rates. This is important for a true N comparison.
- Replicate the check strip and treatment at least 4 times throughout the field, and randomize the strips.
- The area for the trial should be as uniform as possible. Avoid headlands, field edges and waterways.
- Any disease, weed or insect control must be applied perpendicular to the direction of seeding.
- Ensure each plot is wider than swather/straight cut header that is to be used at harvest to ensure treatments aren't mixed. At minimum, a 2' buffer should be left on each side of the plot.
- Use a weigh wagon to measure results for each strip separately.

Full trial protocols (which provide guidelines for accurate on-farm comparisons) and summaries of past results going back to 2013 are available at **ultimatecanolachallenge.ca**.

Far right: This is the experimental bioassay setup to screen plant species for host plant susceptibility or resistance to midge. Each cage contains a single plant and is exposed to eight mated swede midge females for egg laying.

DEVELOPMENT OF A PHEROMONE-BASED MONITORING SYSTEM FOR A NEWLY IDENTIFIED CONTARINIA MIDGE ON THE CANADIAN PRAIRIES

PRINCIPAL INVESTIGATORS: Meghan Vankosky and Boyd Mori, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola
PURPOSE: A new species of midge, closely related to swede midge, was recently discovered in canola crops across the Prairies. Swede midge monitoring is facilitated by pheromone traps that are attractive to adult male midges. Pheromone traps help determine the presence or absence of swede midge, and can be used to time insecticide applications. The purpose of this project is to determine if the new midge species produces pheromones that can be used to develop a pheromone-based monitoring system for this potential canola pest.
PROGRESS: In the first year of this project, midge specimens were collected from canola fields across the Prairies and shipped to our collaborators in the United Kingdom who are working to determine if this species produces pheromones that can be utilized in a pheromone-based monitoring program. Preliminary results suggest female midge produce a pheromone. This compound will be further investigated to determine if it is attractive to male midges and if it can be synthesized for use in pheromone traps.

ECOLOGY OF SWEDE MIDGE — HOST PLANT INTERACTIONS

PRINCIPAL INVESTIGATORS: Boyd Mori, Owen Olfert, Julie Soroka, AAFC Saskatoon
FUNDING: SaskCanola, ADF, WGRF
PURPOSE: The purpose is to investigate host-plant susceptibility or resistance factors to swede midge, with the ultimate aim of identifying host-plant resistance.
PROGRESS: After year 2 of 4, researchers have conducted a literature review of potential plant species that could be hosts for swede midge. The plants were ranked by occurrence (extremely common to rare) in Saskatchewan and the Prairie provinces and a list of species to be tested was created. A colony of swede midge has been established at the Saskatoon Research and Development Centre and initial no-choice bioassays have been conducted on seven

plant species, with experiments ongoing for a further five species. Initial results indicate that all species of plants tested to date can act as swede midge hosts, but the number of developing larvae varies by plant species. Choice tests and behavioural experiments are being organized for the fall and winter.

GETTING MORE BANG FOR YOUR BUZZ: DOES POLLINATION COMPENSATE FOR CANOLA YIELD LOSS UNDER SUB-OPTIMAL MOISTURE, NITROGEN FERTILIZATION, AND/OR SEEDING RATE?

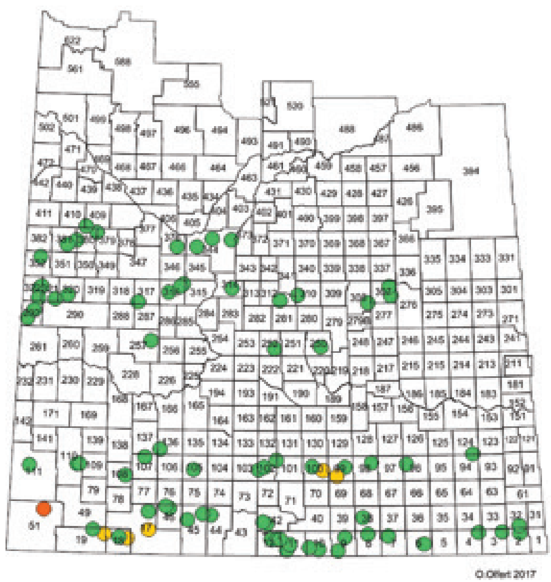
PRINCIPAL INVESTIGATORS: Ralph Cartar, University of Calgary; Shelley Hoover, AF Lethbridge; Steve Pernal, AAFC Beaverlodge; Neil Harker, AAFC Lacombe; Andony Melathopoulos, Oregon State University
FUNDING: Alberta Canola, Beekeepers Commission of Alberta
PURPOSE: The study includes three experiments: (1) How dependent on pollinators are different varieties of commodity canola? (2) How does the timing of water stress affect yield in varieties that differ in the strength of their pollinator-dependence? (3) Does seeding density and/or nitrogen fertilization moderate any yield benefits from pollinators?
PROGRESS: Experiment 1: In the Fall of 2016, using seeds of 23 canola varieties, the research team set up a greenhouse experiment to compare patterns of flowering, nectar production, plant traits, and yield of each variety in the presence and absence of bumble bee pollinators. The data set for this experiment is now complete and being analyzed. Experiment 2: In the Winter of 2017, the team performed another greenhouse experiment on a subset of eight varieties from the first experiment. All were hybrid varieties. This experiment manipulated the timing of water stress (no stress vs vegetative stage vs pod-filling stage) as well as presence of bumble bee pollinators. Data extraction from collected materials is underway. Experiment 3: This field experiment began in the summer of 2017 in Beaverlodge, Alberta. Plants from four different varieties of hybrid canola were grown in and outside of screen tents (see the photo), simulating the presence and absence of pollinators. We recorded plant traits and pollinator visitation during plant development, and harvested plants in September. Data are currently being compiled in the lab. A repeat of this experiment is planned for the summer of 2018.

In April 2017, we welcomed George Adamidis to our research group, who brings an expertise in plant ecology.

Right: Paul Galpern's field team sets up pollinator exposure tents, which prohibit pollinators from visiting flowers. These are required to compare yield for canola with or without pollinators.

SURVEILLANCE NETWORKS FOR BENEFICIAL INSECTS: CAN NATURAL HABITATS SERVE AS INSECT RESERVOIRS, AND DO THEY CONTRIBUTE TO CANOLA YIELD?

PRINCIPAL INVESTIGATOR: Paul Galpern, University of Calgary
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers, CCC
PURPOSE: This project will examine the relationship between the diversity and abundance of beneficial insects and canola production in Western Canada. Specifically, it will address the role of natural habitats near canola fields as reservoirs for pollinators and natural enemies of canola pests as well as the capacity of these beneficial insects to increase seed yield through pollination and pest reduction.
PROGRESS: In 2016, 25,769 bees representing 184 species were collected and identified from 122 locations in southern Alberta. The first meeting of the Prairie Beneficial Insect Working Group took place as scheduled November 7, 2016. For 2017, the goal was to see how the availability of beneficial insects and seed yield change as the distance to natural habitats increases. Sampling targeted pollinators as well as other beneficial insects that are predators of crop pests. Processing and identifying the 75,000 specimens collected this summer is underway.



Far right: Lygus per sweep at various test locations in Saskatchewan in 2017. Green dots indicate 0.04-0.51, Yellow dots indicate 0.51-0.7 and red dots indicate 0.97-1.4.

VALIDATION OF LYGUS AND OTHER INSECT-PEST THRESHOLDS IN COMMERCIAL FARMS THROUGHOUT ALBERTA

PRINCIPAL INVESTIGATOR: Hector Carcamo, AAFC Lethbridge
FUNDING: Alberta Canola, SaskCanola
PURPOSE: The primary objective is to validate lygus thresholds derived from cages in commercial canola fields. Secondary objectives are to assess insecticide sprays for other pests such as flea beetles or cabbage seedpod

Far right: The combination of heat and drought (bottom) has a clear negative effect on yield potential compared to good moisture and temperature conditions, as you can see with the pods from irrigated canola (top).

weevil on canola yield and relate landscape features to lygus distribution.

PROGRESS: In southern Alberta in 2017, conditions were very dry and hot and some canola fields suffered heat stress. Lygus bugs were low in most Alberta fields but there were sufficient numbers for study in three fields. In all three fields, farmers only sprayed the plots, which were 100 m x 40 m wide. The two treatments (sprayed and not sprayed) were replicated four times and randomly assigned to plots separated by about a 40 m unsprayed buffer. Insects were sampled with a sweep net before and after spray (a week later). Hand samples (two rows by 71 cm) were collected at four locations (2-4 m apart) near the two sampling points where lygus were collected. We also collected 10 main racemes to assess cabbage seedpod weevil damage at the two lygus sampling points. As a side study, plants were collected at the pod stage to count diamondback moth larvae and see if the numbers relate to those from sweeping. In Saskatchewan, five canola fields that spanned the majority of the soil zones were monitored weekly with sweep nets and yellow sticky cards. Several growers were asked to participate in the lygus spray study if lygus numbers in fields reached the economic threshold of two per sweep. Lygus bugs were scarce in the weekly surveyed fields and populations levels were never in danger of reaching the economic thresholds. Canola fields in Rural Municipalities across Saskatchewan were surveyed when the canola was in full bloom as part of the cabbage seedpod weevil survey administered by the Prairie Pest Monitoring Network. Across Saskatchewan, no appreciable populations of Lygus bugs (close to 2 per sweep) developed in any of the surveyed canola fields except for RM 51 which did approach the economic threshold at full bloom. (See the map.) In Manitoba, seven fields were monitored for lygus bugs and numbers were very low.

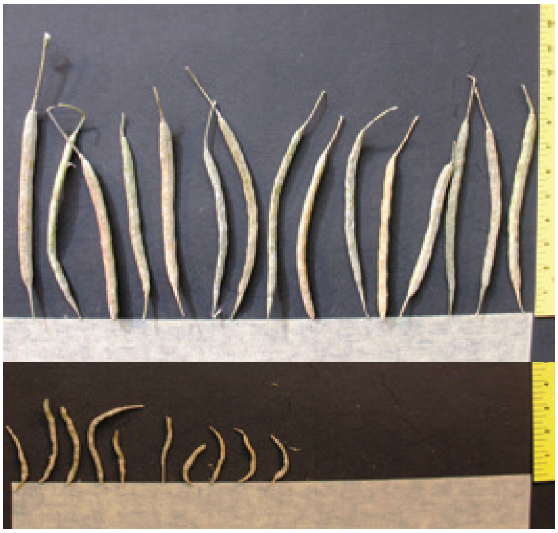
ASSESSING THE INFLUENCE OF BASE GERMINATION TEMPERATURE AND CHEMICAL DESICCANTS ON THE RECRUITMENT BIOLOGY OF CLEAVERS

PRINCIPAL INVESTIGATOR: Chris Willenborg, University of Saskatchewan

FUNDING: SaskCanola

PURPOSE: This project aims to determine the base germination temperature of several cleavers populations in Western Canada and determine the influence of chemical desiccants on cleavers seed properties.

PROGRESS: Base germination temperature of cleavers was found to be similar (2°C) in all populations except Saskatoon, which was 4°C. This is an important finding as previous research had a large base germination range of 2-20°C (Malik and Vanden Born 1987). Growers can use this information to predict optimal times to provide management. For example, growers may not want to spray or till until the majority of seed has germinated, which in this case would be after the first few weeks of April, in our area. For the pre-harvest desiccants part of the study, data indicate that applications of glyphosate plus saflufenacil results in the lowest amount of cleavers dockage. Glyphosate and saflufenacil applications separately and also tank mixed resulted in cleaver seed that was the least viable and had the most electrolyte leakage. High electrolyte leakage from cleavers seeds is related to the poor physiological nature of each seed and most likely results in low viability. Data from 2017 will help clarify the reason why those applications were most efficacious at reducing cleavers seed viability.



IMPACT OF DROUGHT AND HEAT DURING FLOWERING ON CANOLA YIELD

PRINCIPAL INVESTIGATOR: Raju Soolanayakanahally, AAFC Saskatoon

FUNDING: SaskCanola, ADF, AAFC

PURPOSE: Changing precipitation and temperature patterns will cause significant yield losses if drought and heat waves become more common. The project evaluates spring canola lines for stress response to drought, heat and a combination of the two in greenhouse and field conditions. The study employs physiological approaches to identify donor parents for stress-tolerance breeding. The ultimate aim is to get more yields per drop of water. For this purpose, a set of diverse canola lines was grown in greenhouse under four water supply/temperature combinations during flowering: (1) Irrigated plants under optimal temperature (23°C), (2) Drought under optimal temperature (23°C), (3) Irrigated plants under hot ambient temperature (29°C) and (4) Drought under hot ambient temperature (29°C).

PROGRESS: Photosynthetic activity (carbon fixation and water loss through stomata), different components of seed yield, oil content and its composition were measured under the four conditions. Preliminary results showed a predominant negative effect of heat which decreased seed yield by more than 85 per cent. This effect was noticed and similar for both irrigated and non-irrigated plants, suggesting a heat effect on floral structures and reproduction process. The number of pods as well as the average number of seeds per pod had significantly decreased when plants were exposed to heat. (See the image). Drought had a significant but lesser effect on seed yield under optimal temperature. Pods and seed number were affected more by combined heat and drought exposure than by exposure to a single stressor, showing a cumulative effect. Oil yield decreased remarkably with heat and to a lesser extent with drought, following the same pattern as seed yield.

INTEGRATED APPROACH FOR FLEA BEETLE CONTROL - ECONOMIC THRESHOLDS, PREDICTION MODELS, LANDSCAPE EFFECTS AND NATURAL ENEMIES

PRINCIPAL INVESTIGATOR: Alejandro Costamagna, University of Manitoba
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
PURPOSE: Major objectives of the project are to validate the current nominal threshold for flea beetles in canola, determine natural enemies impacting flea beetle populations, identify landscape features promoting effective natural enemies, and develop models for flea beetle populations based on weather and crop variables to provide timely prediction of the flea beetle population.
PROGRESS: Researchers conducted 40 trials to determine economic threshold of flea beetles, and 78 grower fields were sampled for flea beetle and its natural enemy populations. In these fields, landscape maps were drawn for 2-3 km area from a focal point. In these studies, they assessed canola phenology, defoliation by flea beetles and abundances of flea beetles and natural enemies. Molecular gut-content analysis of field-collected predator species was done to see which predators fed on flea beetles. Processing of 2017 samples and analysis of data from previous years is underway.

TOXICOPATHOLOGICAL DETERMINATION OF SAFE DOSE RANGES OF NEONICOTINOIDS FOR HONEY BEE COLONIES

PRINCIPAL INVESTIGATOR: Elemir Simko, Western College of Veterinary Medicine, University of Saskatchewan
FUNDING: SaskCanola, WGRF, ADF, MITACS, Saskatchewan Beekeepers Development Commission, Canadian Honey Council, North American Pollinator Protection Campaign
PURPOSE: The 'gold standard' mammalian safety toxicopathological tests are very sensitive and veterinary pathologists use them to detect sublethal toxic effects of candidate drugs, pesticides and other chemicals in laboratory animals in order to determine the safe dose range. Comparable approaches have not been developed for honey bees. WCVM has the expertise and research capacity to adopt this mammalian 'gold standard' safety evaluation to honey bees and to determine the safe dose range for the three most commonly used neonicotinoids in agriculture.
PROGRESS: Adaptation of mammalian safety histopathology tests to honey bees has begun. Researchers assembled databases of normal histology of the brain of worker bees and the reproductive tracts of drones and queens. Individual larvae and pupae of workers, drones, and queens were exposed to incremental doses of neonicotinoids during the summer 2017 and histopathological evaluation of the effects is in progress. We also performed a large chronic comparative toxicity study and determined that high environmentally realistic doses of neonicotinoids affect colony size and honey collection, whereas there was no effect detected in colonies exposed to medium environmental doses of neonicotinoids.

DEVELOPMENT AND IMPLEMENTATION OF A WEATHER-BASED, NEAR REAL-TIME, CROP INSECT PEST MONITORING/PREDICTION MODEL AND PROGRAM FOR ALBERTA

PRINCIPAL INVESTIGATOR: Daniel Itenfisu, AF
FUNDING: Alberta Canola, AF
PURPOSE: The aim is to develop and implement a provincial weather-based near real-time (NRT) insect pest prediction model as a web-based risk management tool for three significant insect pests: bertha armyworm, alfalfa weevil and wheat midge. Considering significant interest from producers on flea beetle dynamics and prediction, we expanded our project to include striped flea beetle and crucifer flea beetle. The models will assist in timely and informed decision making for effective pest management.
PROGRESS: The project was extended for a year with funding to collect additional field data on wheat midge, alfalfa weevil and canola flea beetles. Phenology and life history of the three pests and their natural enemies along with crop phenology were monitored across 17 sites in Alberta. Weather monitoring occurred at all sites. Spring soil sampling, yellow-sticky trap monitoring and wheat head dissections were conducted for wheat midge. Alfalfa weevil adults and larval populations were monitored in forage and seed crops. Canola flea beetles were monitored using yellow-sticky traps from seeding to pod maturity at seven sites. Weekly weather-based prediction maps were produced for each species. Field data quality control and data analyses across sites and years leading to improved phenology models for each species is underway.

COORDINATED SURVEILLANCE, FORECASTING AND RISK WARNING SYSTEMS FOR FIELD CROP INSECT PESTS OF THE PRAIRIE ECOSYSTEM

PRINCIPAL INVESTIGATOR: Owen Olfert, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers, WGRF, SPG, AWC
PURPOSE: The aim is to develop and implement insect surveillance programs to identify risks to crop production from pest species and to highlight and conserve their natural enemies.
PROGRESS: This project is currently in Year 4 of 5. Surveys were conducted for key field-crop pests, including grasshoppers, wheat midge, cabbage seedpod weevil, bertha armyworm and pea leaf weevil, with data collected from more than 6,000

sites in Alberta, Saskatchewan and Manitoba. Sentinel sites were monitored for flea beetles, cutworms, swede midge and cereal leaf beetle. Regional forecast and distribution maps for the insects monitored will be made available in early 2018 (some provincial maps are already available). The 2017 survey saw an increase in the area surveyed in Saskatchewan and Alberta for some pests, including pea leaf weevil and cabbage seedpod weevil. The project team produced 17 Weekly Updates in 2017 (available online using the Prairie Pest Monitoring Network blog: **http://prairiepestmonitoring.blogspot.ca/**)

HARVEST MANAGEMENT

PRE-HARVEST HERBICIDE AND DESICCATION OPTIONS FOR STRAIGHT-COMBINING CANOLA: EFFECTS ON PLANT AND SEED DRY-DOWN, YIELD AND SEED QUALITY

PRINCIPAL INVESTIGATOR: Chris Holzapfel, Indian Head Agricultural Research Foundation
FUNDING: SaskCanola, Manitoba Canola Growers
PURPOSE: This project was initiated in 2017 to evaluate potential pre-harvest herbicide and desiccant options and their effects on crop and seed dry-down and seed quality when straight-combining canola. The project is intended to provide guidelines regarding potential benefits of pre-harvest herbicide or desiccant applications when straight-combining canola and make product recommendations tailored to specific needs and expectations.
PROGRESS: The first year of field trials had locations at Indian Head, Melfort and Scott, Saskatchewan and Melita, Manitoba. Trials included pod-shatter resistant Roundup Ready and Liberty Link canola varieties treated with either glyphosate alone (Liberty Link only), saflufenacil alone, glyphosate plus saflufenacil, diquat or glufosinate ammonium (Roundup Ready only). Trials also had untreated checks. The major dependant variables of interest are visual ratings of stem dry-down, seed moisture at time of harvest, whole plant moisture at time of harvest, seed size and percent green seed. The project will run for three growing seasons.

GENETICS

MAPPING AND INTROGRESSION OF THE HIGHLY EFFECTIVE *BRASSICA RAPA* BLACKLEG RESISTANCE GENE RLM11 INTO SPRING-TYPE *BRASSICA NAPUS*

PRINCIPAL INVESTIGATOR: Hossein Borhan, AAFC Saskatoon
FUNDING: ADF, SaskCanola and WGRF
PURPOSE: Blackleg disease of canola is a persistent threat to canola production in Canada and most other canola-producing countries. Using canola varieties with resistance (R) genes against blackleg pathogen is the most effective way to control blackleg. R-genes work by recognizing matching target genes in the pathogen, termed avirulence (*Avr/avr*) genes. For a canola R-gene to be effective, it is best if the R-gene recognizes an *Avr* gene that is present in the majority of blackleg isolates found in a canola field. An example of such an R-gene is *Rlm11* that recognises an *Avr* gene named *AvrLm11* in the blackleg pathogen. Our recent survey shows that *AvrLm11* is present in 95 per cent of blackleg field isolates in western Canada. We are conducting a research project to determine the location of *Rlm11* and help breeders to move *Rlm11* into commercial canola cultivars. A canola cultivar with the *Rlm11* gene will be effective in preventing blackleg infection in canola farms across the Prairies.
PROGRESS: This is a new project without much to report at this time.

DEVELOPING CANOLA GERMPLASM WITH DIVERSE MECHANISMS TO ENHANCE THE DURABILITY OF CLUBROOT RESISTANCE

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon
FUNDING: SaskCanola, WGRF
PURPOSE: The main objective is to identify and characterize clubroot resistance against a new group of clubroot, pathotype 5x, found in Alberta and virulent towards all current clubroot-resistant (CR) canola cultivars in Canada. Over the years, we identified a large number of CR sources or genes against common pathotype 3 other pathotypes found in Alberta, but the resistance to this new pathotype group is unknown. This project will assess these materials plus additional CR candidates, and identify promising CR genes or gene combinations against 5x.
PROGRESS: The initial work found several potential candidates against a mixed population of 5x pathotypes. Further work was carried out by introgression of selected CR genes into the background of *Brassica napus*, and in some cases pyramiding them into breeding lines for development of multiple CR-gene hybrids. Selected genes or gene combinations were assessed using specific 5x populations that showed different virulence (or aggressiveness) toward resistant canola cultivars. This provided a better understanding of resistance differentiation against different 5x populations. Molecular CR mechanisms are being studied for single and multiple CR genes to develop canola germplasm with different modes of action for clubroot resistance.

Right: Effect of high temperature on QR expression measured by stem lesion size. Horizontal arrows identify the scar of fallen petiole infected with Leptosphaeria maculans, *while vertical arrows indicate the upper and lower edges of the lesion. Plants were exposed to moderate (22°C) or high (32°C) temperatures at early flowering stage. The variety on the left side was Westar, and the other two are common commercial varieties with QR.*

Far right: The cultivar 45H29 (left) is susceptible to pathotype 5x (LG-2) of Plasmodiophora brassicae *(clubroot) while the two hybrids (middle and right) carrying double resistance genes are partially resistant (tiny galls).*

UNDERSTANDING THE MECHANISMS FOR RACE-SPECIFIC AND NON-SPECIFIC RESISTANCE FOR EFFECTIVE USE OF CULTIVAR RESISTANCE AGAINST BLACKLEG OF CANOLA IN WESTERN CANADA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers, ASP (GF2)
PURPOSE: This study aims to characterize blackleg resistance used in Western Canada, and assess potential influence of environmental factors, especially hot, dry conditions, on the expression of resistance to better understand the mechanisms of different types of resistance.
PROGRESS: Race non-specific resistance was assessed with eight selected commercial canola cultivars from four major seed companies. These cultivars carry only the R-genes *Rlm1* and/or *Rlm3*. Three of the cultivars with slightly different levels of resistance on cotyledons were assessed further using cotyledon and petiole inoculation. Results showed that the spread of pathogen into the stem was more limited on commercial cultivars than on Westar and the infection developed more slowly in the stem of commercial cultivars. It appears that many Canadian commercial cultivars carry non-specific blackleg resistance, while the common R-genes *Rlm1* and *Rlm3* are no longer effective in most regions of western Canada. Analysis has been conducted with three selected R-genes and three commercial varieties with quantitative resistance (QR) to differentiate molecular mechanisms of blackleg resistance. Preliminary data analysis has identified unique modes of action, especially between major genes and QR. Once completed, the information can aid in resistance deployment strategies for blackleg management. Additionally, these QR varieties were also assessed under a heat-wave temperature condition (32°C) for blackleg/stem canker resistance performances because high temperatures have been suspected to reduce the effectiveness of QR. Early results have shown that the QR gene(s) in common canola varieties are not affected by high temperatures around the rosette or early flowering stages of canola.

ENHANCING THE DURABILITY OF CLUBROOT RESISTANCE WITH MULTIPLE RESISTANCE GENES

PRINCIPAL INVESTIGATORS: Tao Song and Gary Peng, AAFC Saskatoon
FUNDING: SaskCanola, WGRF
PURPOSE: For optimal deployment of new clubroot-resistant (CR) genes, this study hopes to assess whether the better method is to pyramid them into a single hybrid or rotate among CR genes. Researchers also want to know whether longer crop rotations, which help reduce pathogen inoculum in the soil, can benefit resistance durability when multiple CR genes are used. The aim is also to identify potential downsides, if any, for using CR genes under low pathogen pressure background such as most fields in Saskatchewan and Manitoba.
PROGRESS: Initially, the work has been focused on the assessment of 19 single- and multi-gene hybrids against different populations of the pathotype 5x identified in Alberta. There is differentiation of resistance depending on the population, but two of the multi-gene combinations seemed to provide substantial resistance relative to the control 45H29. Further studies looked at repeated exposure of partially resistant single- and double-gene hybrids against a 5x population and a highly resistant single-gene hybrid against a low level of pathotype 3 population. The initial results (after three cycles of exposure) showed little change in disease severity, indicating the virulence of the pathogen (or pathotypes) might not have changed substantially. Additionally, transcriptome analysis (for RNA sequencing) has been used to understand the molecular mechanisms of double-gene hybrids in resisting multiple pathotypes of clubroot, including 5x vs. the single-gene hybrid susceptible to 5x. The information will assist the development of CR-gene deployment for maximum durability of clubroot resistance.

DEVELOPING NEAR-ISOGENIC *BRASSICA NAPUS* LINES FOR DIFFERENTIATING PATHOTYPES OF *PLASMODIOPHORA BRASSICAE*

PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC Saskatoon
FUNDING: WGRF, ADF and SaskCanola
PURPOSE: This project aims to develop *B. napus* lines each with a single unique clubroot resistance gene from

Brassica vegetable species. These lines could be used for differentiating pathotypes of *P. brassicae* and rapid incorporation into canola variety development programs.
PROGRESS: This project is wrapping up and researchers have obtained doubled-haploid *B. napus* plants containing eight single clubroot-resistance genes.

IDENTIFICATION AND GENETIC MAPPING OF *BRASSICA NAPUS* FOR RESISTANCE TO PATHOTYPE 5X OF *PLASMODIOPHORA BRASSICAE*

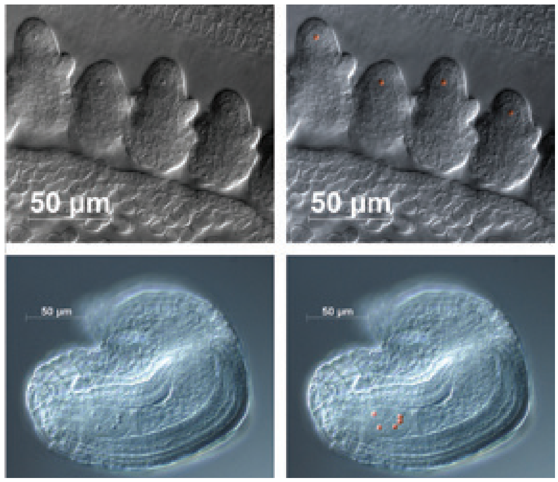
PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers, ASP (GF2)
PURPOSE: The project aims to identify new sources of *B. napus* for resistance to pathotype 5x, map clubroot resistance (CR) genes and develop markers tightly linked to the genes for use in marker-assisted breeding. It will then work to facilitate the rapid incorporation of multiple CR genes into elite canola breeding lines.
PROGRESS: More than 300 genetic markers were identified through genotyping by sequencing of 189 *Brassica napus* accessions. Fifty markers were associated with resistance to pathotype 5x. *B. napus* lines resistant to pathotypes 3A, 2B and 3D were also identified.

INTROGRESSION OF DISEASE RESISTANCE FROM *BRASSICA NIGRA* INTO CANOLA USING NEW-TYPE *BRASSICA NAPUS*

PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC Saskatoon
FUNDING: SaskCanola, ADF
PURPOSE: The project aims to identify clubroot resistance and blackleg resistance genes in *B. nigra* and transfer the genes into canola.
PROGRESS: Researchers have genetically mapped a clubroot resistance gene in *B. nigra* and obtained BC2 progenies from interspecific crosses between *B. napus* and the *B. nigra* line. Both clubroot and blackleg resistances in the BC2 populations have been confirmed.

FIELD EVALUATION OF A VALUABLE GERMPLASM RESOURCE DESIGNED TO DISSECT COMPLEX TRAITS IN *BRASSICA NAPUS* (THE NESTED ASSOCIATION MAPPING POPULATION)

PRINCIPAL INVESTIGATOR: Sally Vail, AAFC Saskatoon
FUNDING: SaskCanola, Manitoba Canola Growers, Alberta Canola
PURPOSE: Considerable resources have been invested over the past four years to develop the spring *Brassica napus* Nested Association Mapping (NAM) population. This is now completed with over 2,500 recombinant inbred lines (RILs) which represent recombination of 50 diverse founder lines with a reference line. The population structure was designed to decipher complex traits that are often controlled by many genes and interacting biochemical pathways. Continued support for the NAM project facilitates building of an industry-wide resource which has the potential to benefit the entire canola value chain.
PROGRESS: In the 2017 field season, the diverse founder lines were assessed in Manitoba and Alberta trials and a subset of the RILs alongside the founder lines were tested in Saskatchewan. Trials were leveraged by various collaborators studying seed quality and physiological traits as well as digital plant phenotyping technologies. In collaboration with NAM industry consortium partners, bulking up of RIL seed quantities will be initiated with seed production in greenhouses in anticipation of further increasing lines in the future.



Far right: These images show micro dissection of Boechera ovules at different development stages, looking for genetic triggers for apomixis. Credit: Unpublished data from Paride Rizzo.

COMPARATIVE GENOMICS OF APOMICTIC PLANTS: ADVANCING NOVEL TOOLS FOR NICHE BREEDING

PRINCIPAL INVESTIGATOR: Tim Sharbel, Global Institute for Food Security
FUNDING: SaskCanola, ADF
PURPOSE: The aim is to generate a high-quality genome of Boechera, a wild Brassicaceae that can reproduce apomictically. Apomictic plants produce seeds without pollen (male) fertilization, and thus all offspring are genetic clones of the mother. The ability to introduce apomixis into canola would enable single-generation hybrids to be produced and fixed genetically, regardless of the genetic complexity behind the phenotypic traits of interest. This could provide the opportunity to produce more genetically variable canola lines with ease, thereby enabling breeders to exploit niche breeding and rapidly breed varieties adapted to changing environmental conditions.
PROGRESS: A draft genome of Boechera has been produced, and a high-quality annotation is underway, looking for the genetic triggers for apomixis. Ovules have been microdissected at specific developmental stages for five out of six genotypes for which additional lower-coverage genomes are underway.

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